An Introduction to ALMA

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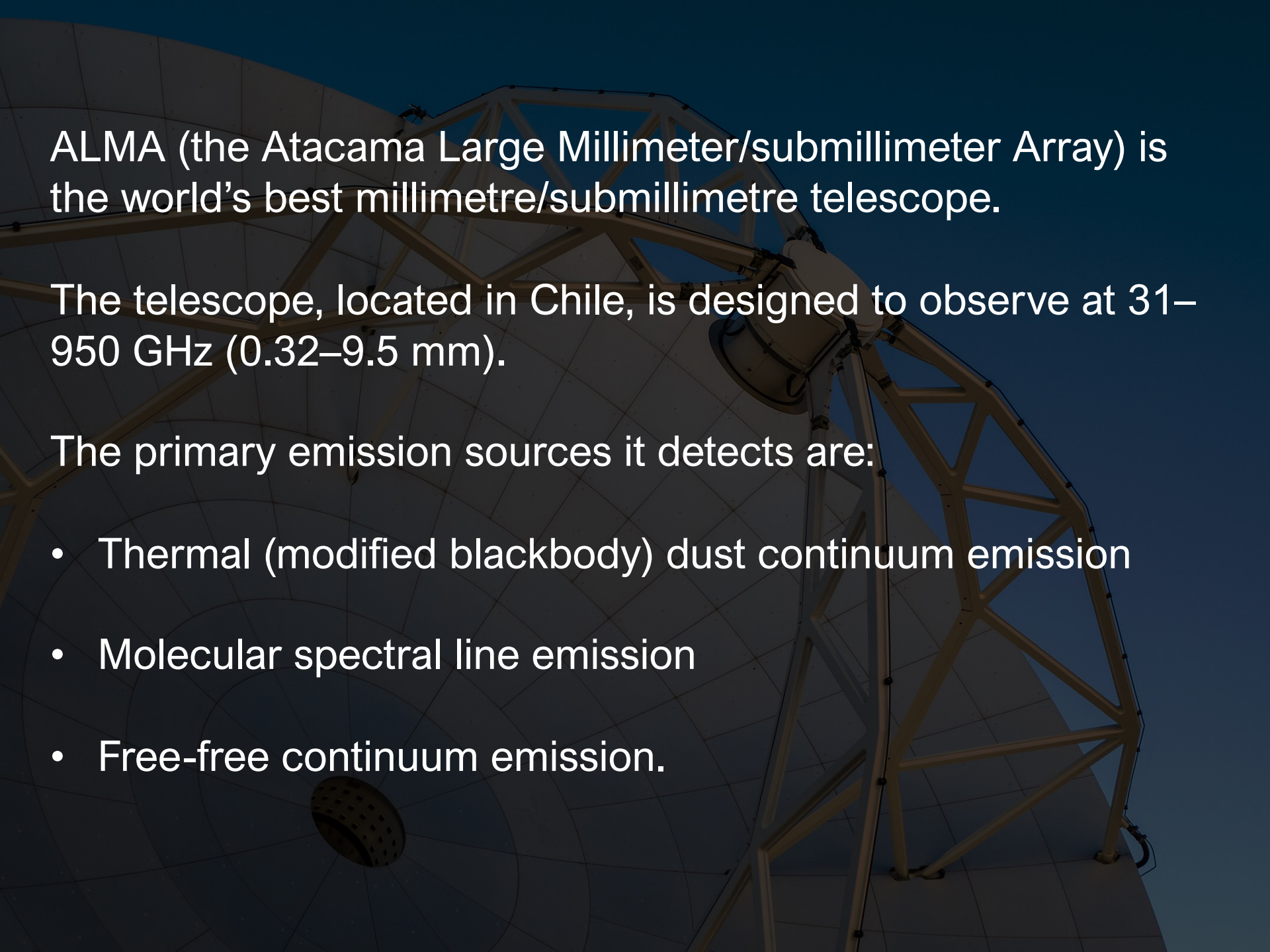


ALMA (the Atacama Large Millimeter/submillimeter Array) is the world's best millimetre/submillimetre telescope.

The telescope, located in Chile, is designed to observe at 31–950 GHz (0.32–9.5 mm).

The primary emission sources it detects are:

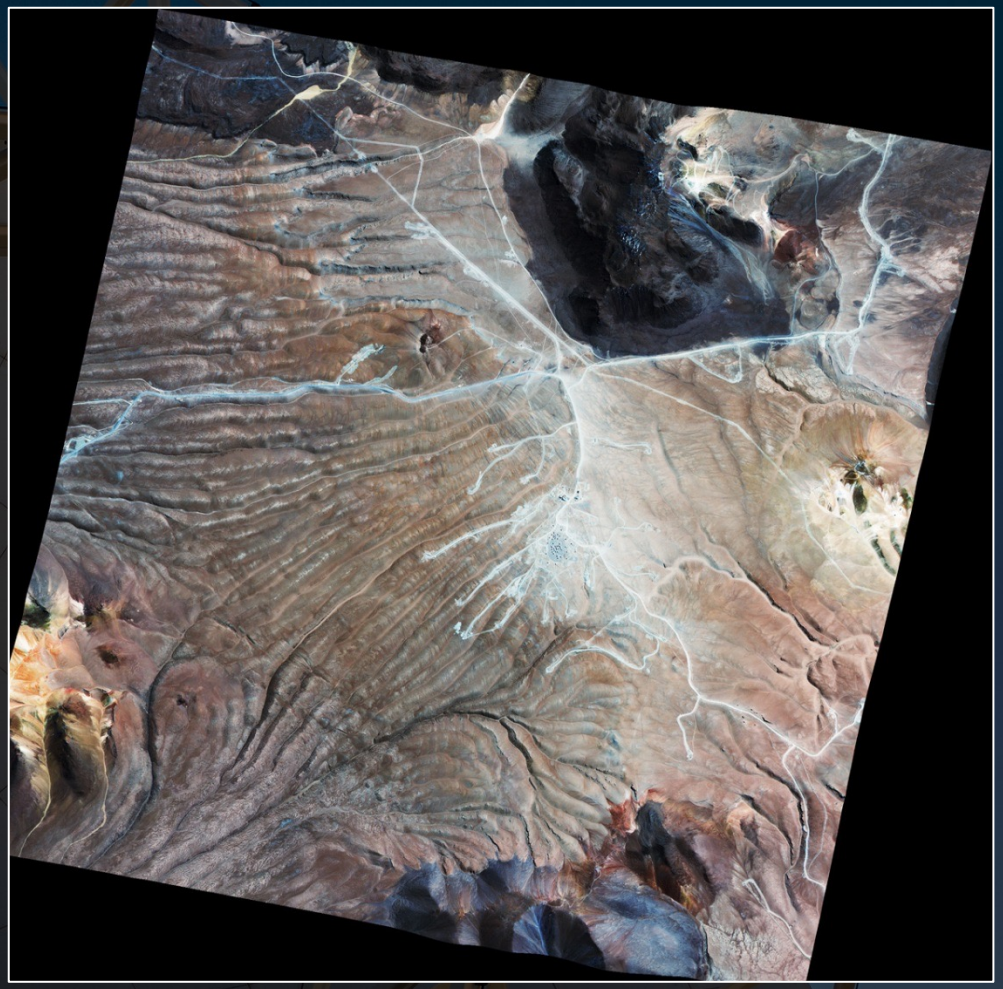
- Thermal (modified blackbody) dust continuum emission
- Molecular spectral line emission
- Free-free continuum emission.

Some of the science performed with ALMA includes:

- Detecting dust emission from high-redshift galaxies (up to z=10)
- Using CO to measure redshifts for distant galaxies
- Imaging molecular gas and dust in nearby galaxies
- Examining the formation of protostellar objects in molecular clouds
- Identifying the chemical composition of molecular gas around protostellar objects
- Resolving protoplanetary disks
- Observing the formation of molecules and dust grains around evolved stars and supernovae
- Studying the physics of the Sun

ALMA is located in the Atacama Desert, a high-altitude desert in Chile.

Because the air is cold and dry, the site is ideal for observing in submillimetre and millimetre bands.



(Credit: Aerophotogrammetry Sevice, Chilean Air Force)

The Array Operations Site (AOS) is located at an elevation of 5000 m.

Access to the site is highly restricted, even for people working with the observatory.

(Credit: ALMA (ESO/NAOJ/NRAO)/A. Caproni (ESO)

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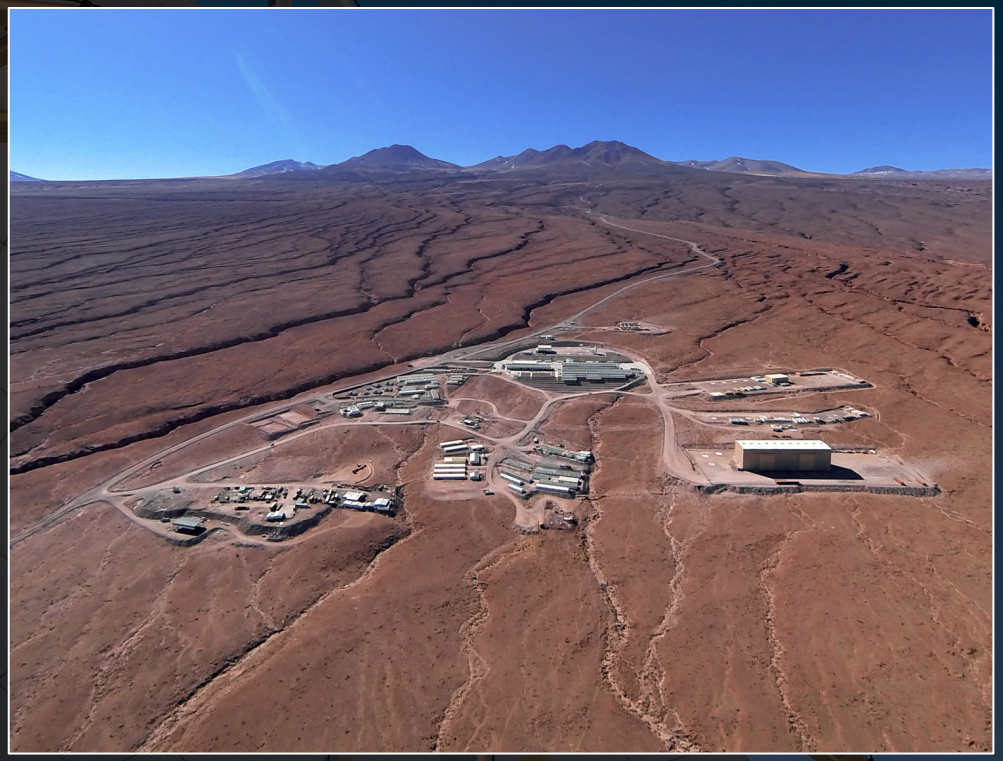
(Credit: ESO/S. Fandango)

Workshops for the telescope are located at the Observation Support Facility (OSF) at an elevation of 2900 m.

Public tours of the site are available.



(Credit: ESO)

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(Credit: ALMA (ESO/NAOJ/NRAO), W. Garnier (ALMA). Acknowledgment: General Dynamics C4 Systems)

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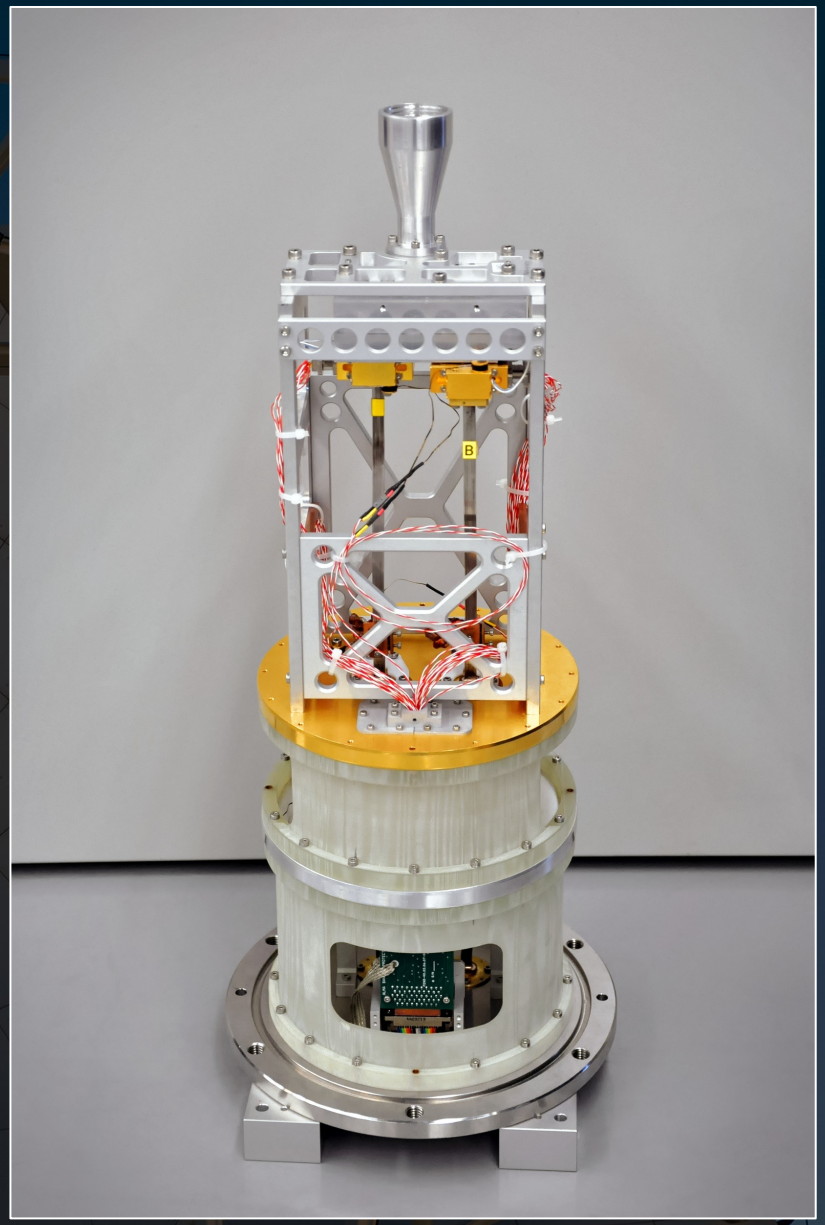
ALMA operations are managed from the Joint ALMA Office on the European Southern Observatory campus in Santiago.

(Credit: ESO & ALMA (ESO/NAOJ/NRAO))

ALMA uses multiple sets of heterodyne receivers.

9 bands will be available in Cycle 10.

The data are initially processed through a couple of large correlators located at the AOS.



(Credit: ASIAA/NAOJ/ESO/S. Guisard (www.eso.org/~sguisard))

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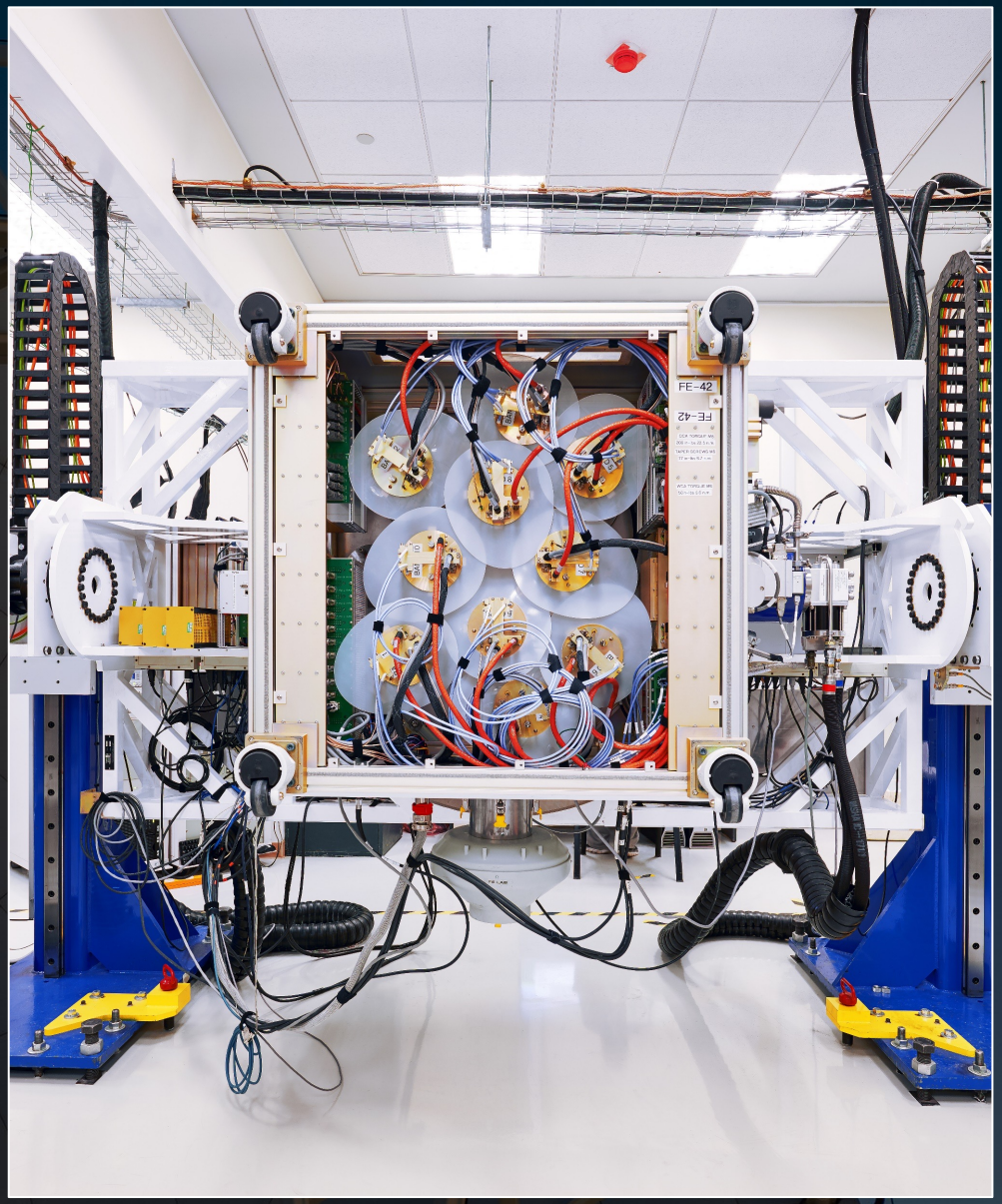

(Credit: Enrico Sacchetti/ESO)

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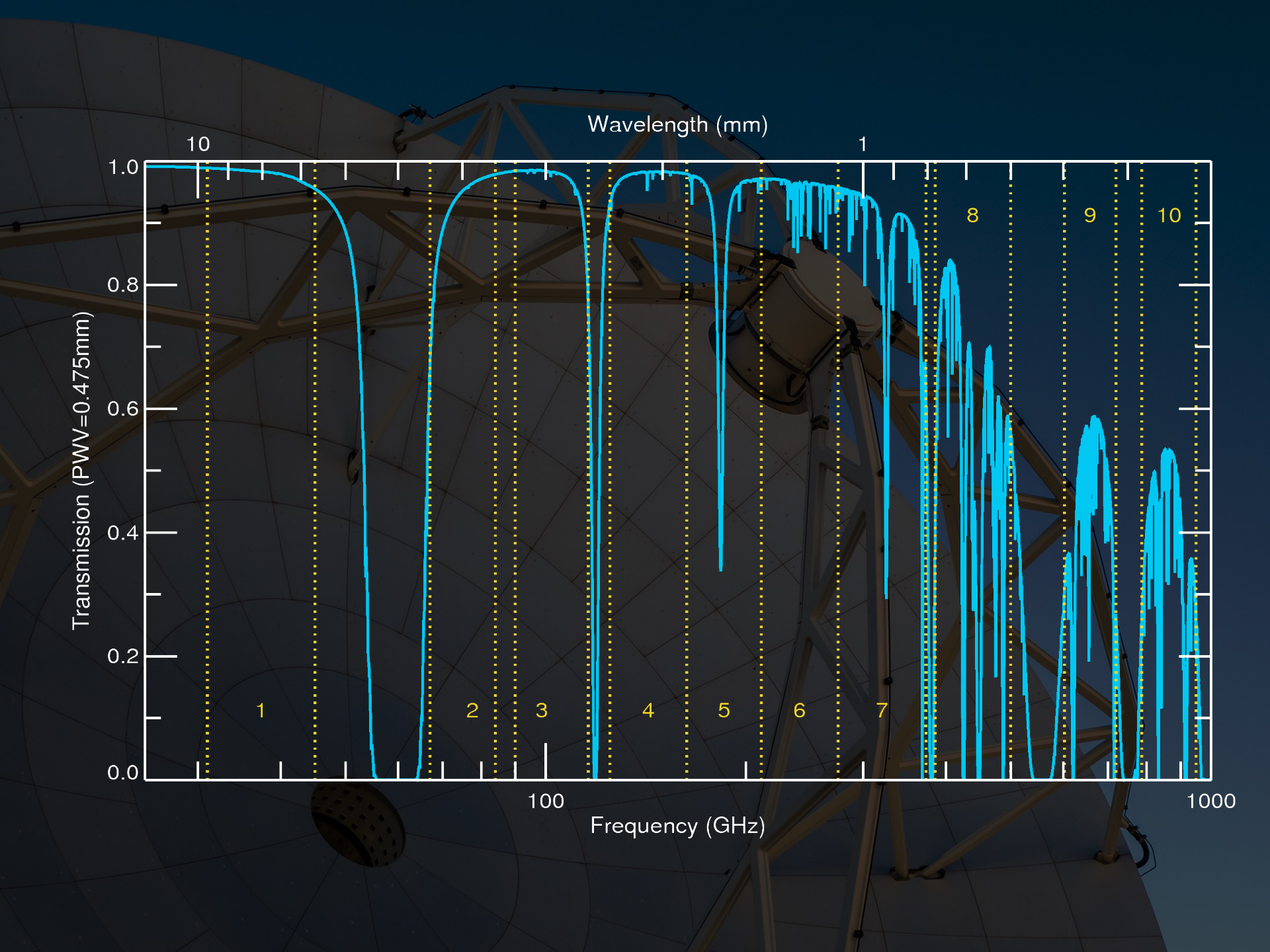
(Credit: ESO/M. Alexander)

Band	Frequency (GHz)	Wavelength (mm)	Primary Beam (arcsec)	Angular Resolution (arcsec)	
				Compact Configuration	Extended Configuration
1	35-50	6.0-8.6	148	8.0	0.099
3	84-116	2.6-3.6	63	3.4	0.042
4	125-163	1.8-2.4	43	2.3	0.028
5	163-211	1.4-1.9	30	1.8	0.023
6	211-275	1.1-1.4	25	1.5	0.018
7	275-373	0.80-1.09	19	1.0	0.028
8	385-500	0.60-0.78	14	0.74	0.046
9	602-720	0.42-0.50	9.2	0.52	0.033
10	787-950	0.32-0.38	7.1	0.39	0.024


Wavelength (mm)
10
1
1.0
0.8
0.6
0.4
0.2
0.0
Transmission (PWV=0.475mm)
1
2
3
4
5
6
7
8
9
10
100
1000
Frequency (GHz)

ALMA has three subarrays that observe different-sized structures:

- The main array (50 antennas with 12m diameters)
- The Atacama Compact Array (12 antennas with 7m diameters)
- The total power antennas (4 antennas with 12m diameters)

(Credit: ESO)

The main (12m) array can be reconfigured in different ways to achieve different angular resolutions.

- Short baseline configurations image extended emission.
- Long baseline configurations resolve small structures.

(Credit: ESO/P.Martinez)

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- Long baseline configurations resolve small structures.

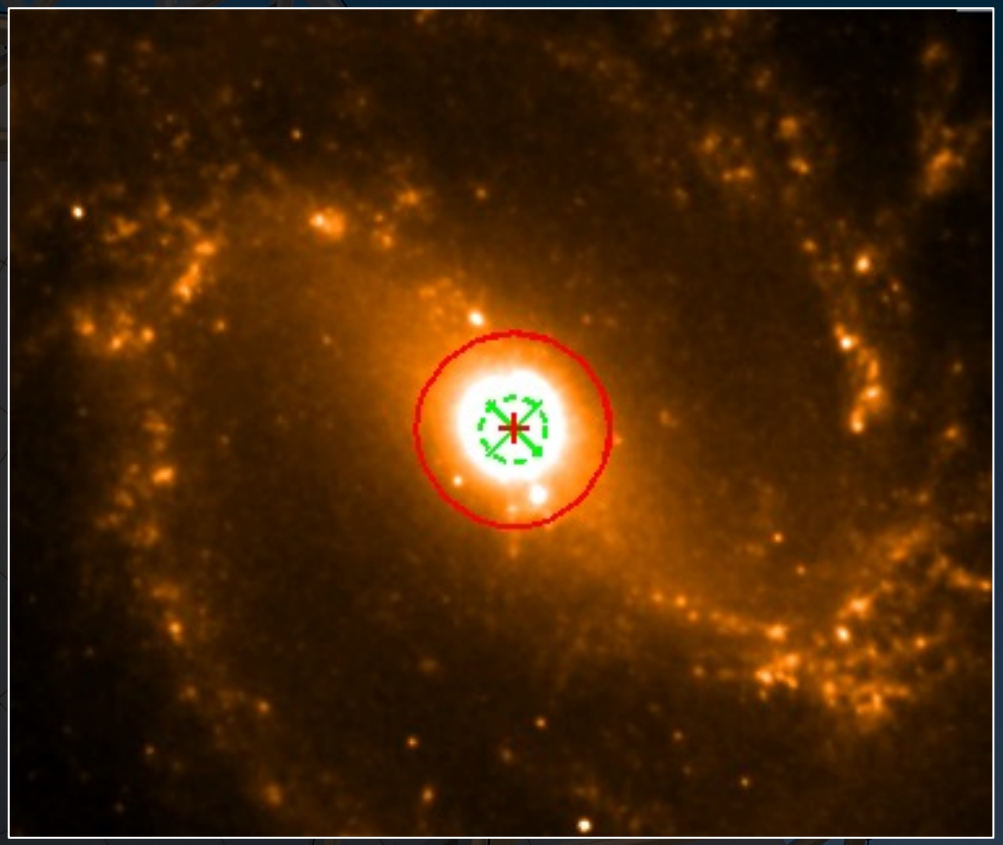
(Credit: ESO)

The ACA is used to image large-scale structures that are usually resolved out by the 12m array. It can also be used as a stand-alone array when resolving structure is unimportant.

The total power antennas are used to detect large-scale line emission resolved out by both the 12m and ACA arrays. (Continuum-imaging capabilities may be added in the future.)

The most basic field that can be imaged by ALMA is a single pointing.

However, ALMA can also image multiple pointings as part of one set of observations or mosaic a rectangular field.



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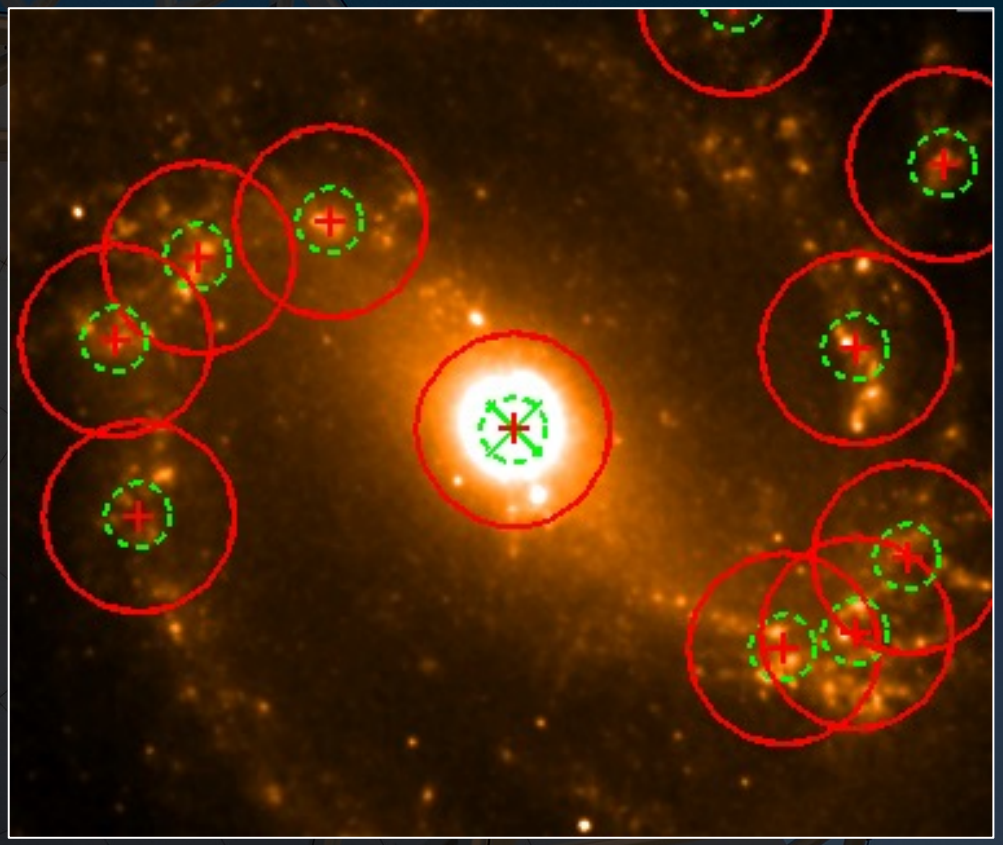

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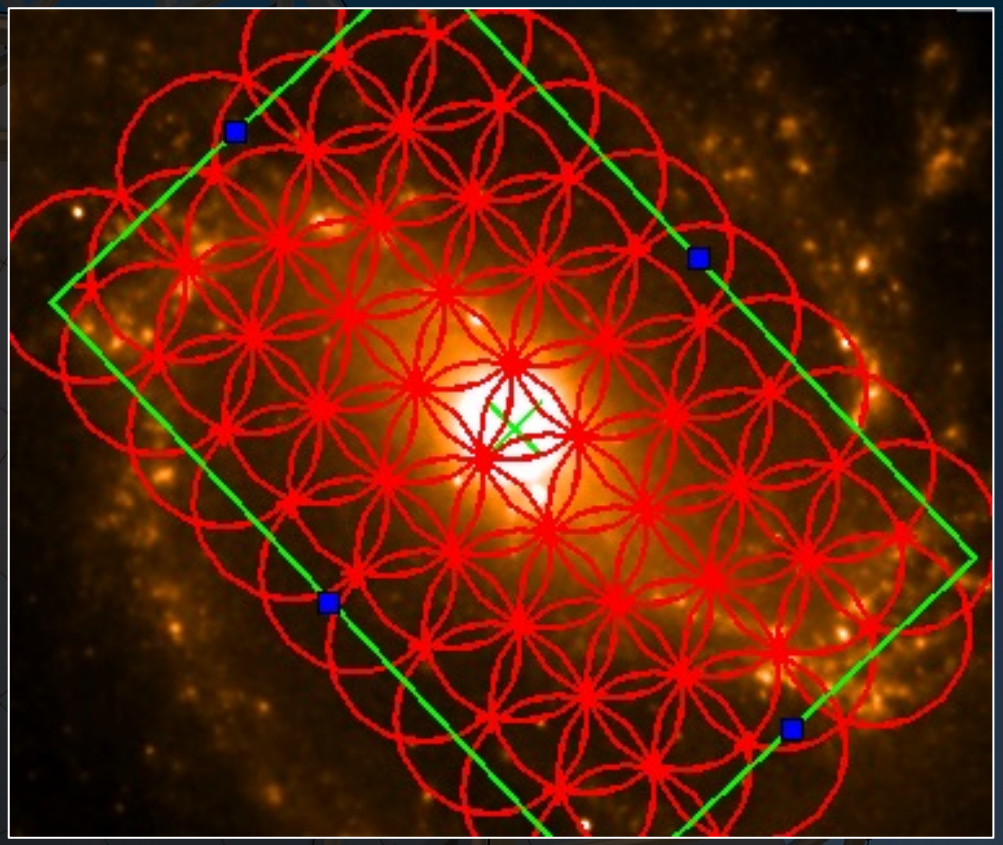
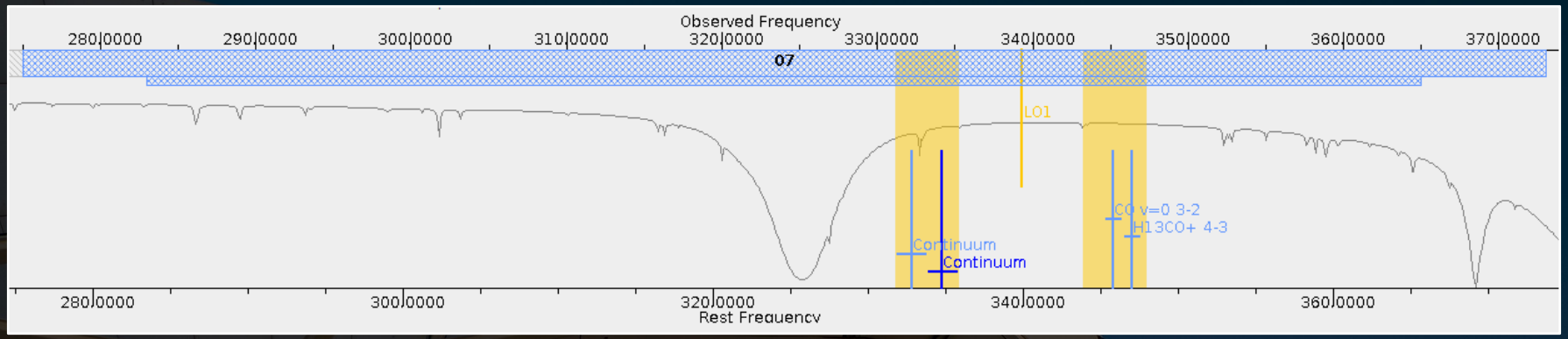


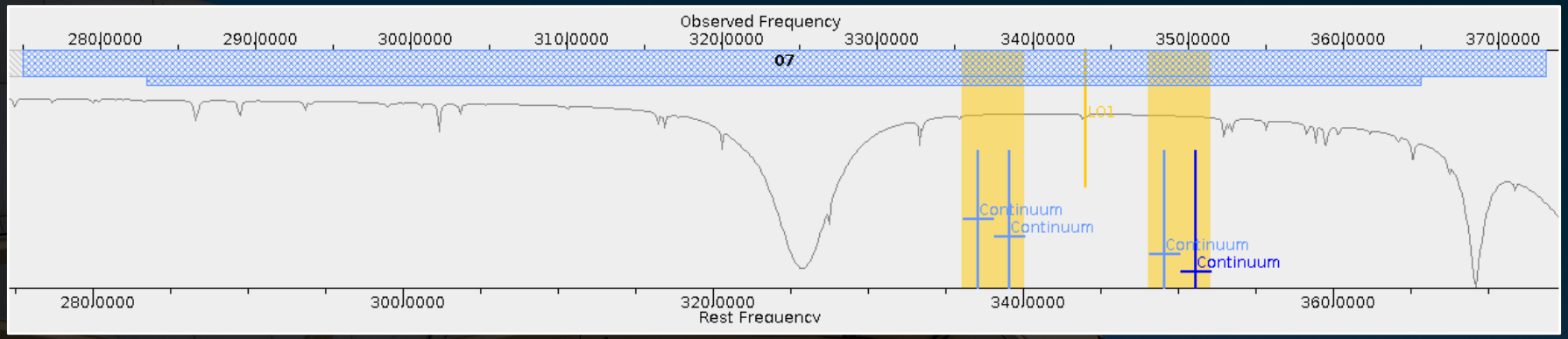


ALMA currently offers three types of spectral set-ups.

- Spectral line imaging mode
- Continuum mode
- Spectral scan mode

In all three modes, each observation is normally performed with 4 or more spectral windows (spws), with two spws on each side of a local oscillator signal (except for bands 9 and 10, where all the spws are on one side of a local oscillator).

Each spw can contain up to 3840 channels (or 4096 for the ACA).



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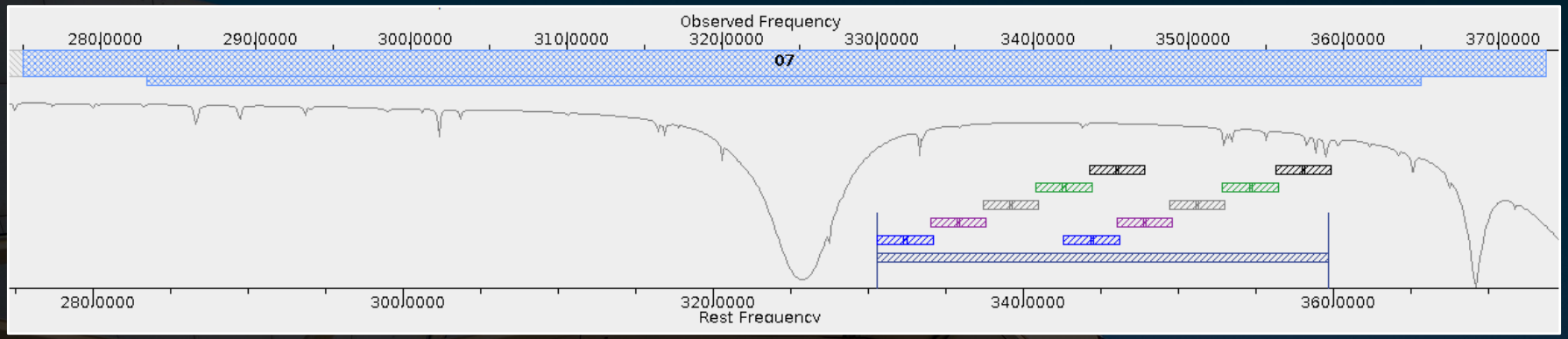

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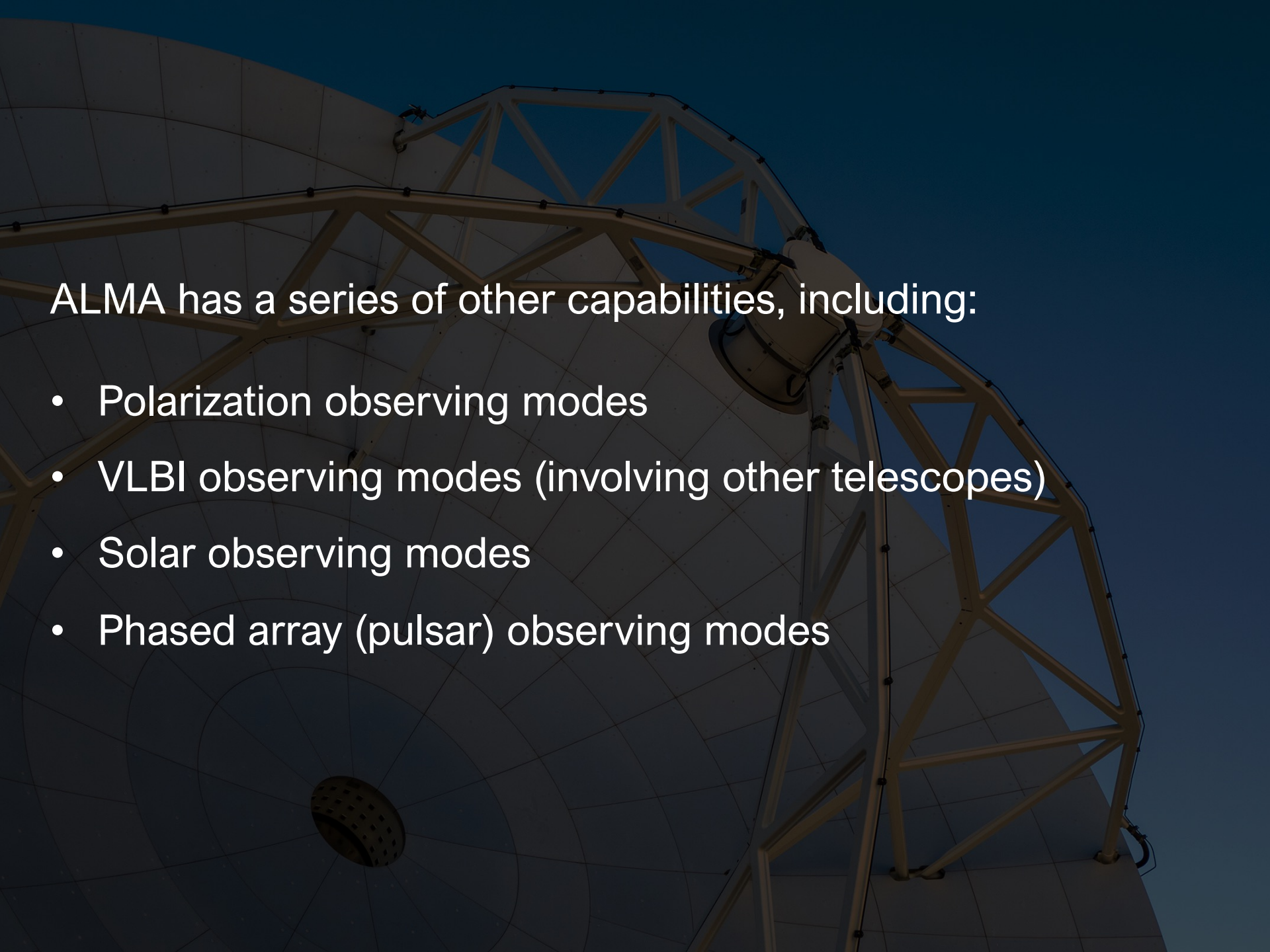


ALMA has a series of other capabilities, including:

- Polarization observing modes
- VLBI observing modes (involving other telescopes)
- Solar observing modes
- Phased array (pulsar) observing modes

For Cycle 10, ALMA will be offering the following new capabilities:

- Band 1 observing capabilities (available from March 2024)
- Total Power spectral scans observations
- Improved digitization of the data from the 12m array (for improved sensitivity)
- Band 3 full polarization solar observations (using only the 12m array)
- Phased array modes in Bands 1, 3, 6, and 7 (used, for example, for observing pulsars)
- VLBI in Bands 1, 3, 6, and 7

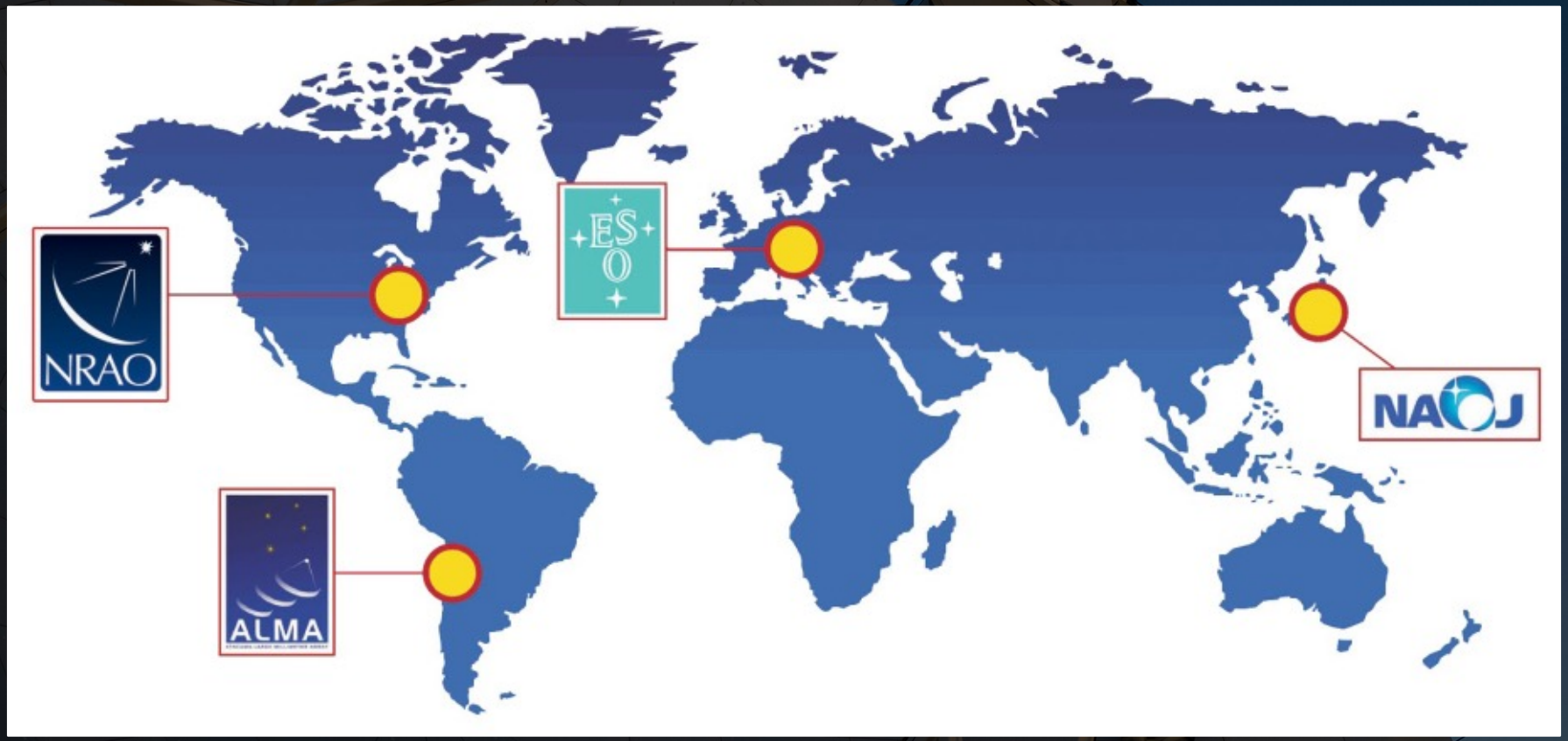
Additionally, ALMA now will accept Joint Proposals where observers can simultaneously apply for time on ALMA and the following observatories:

- JWST
- VLT
- JVLA

This eliminates some of the tricky problems that astronomers encounter when they need to get data from multiple telescopes. They can now submit one proposal instead of multiple proposals.

ALMA is operated by a collaboration between North America, Europe, and East Asia. Regional activities are coordinated by ALMA Regional Centres (ARCs).

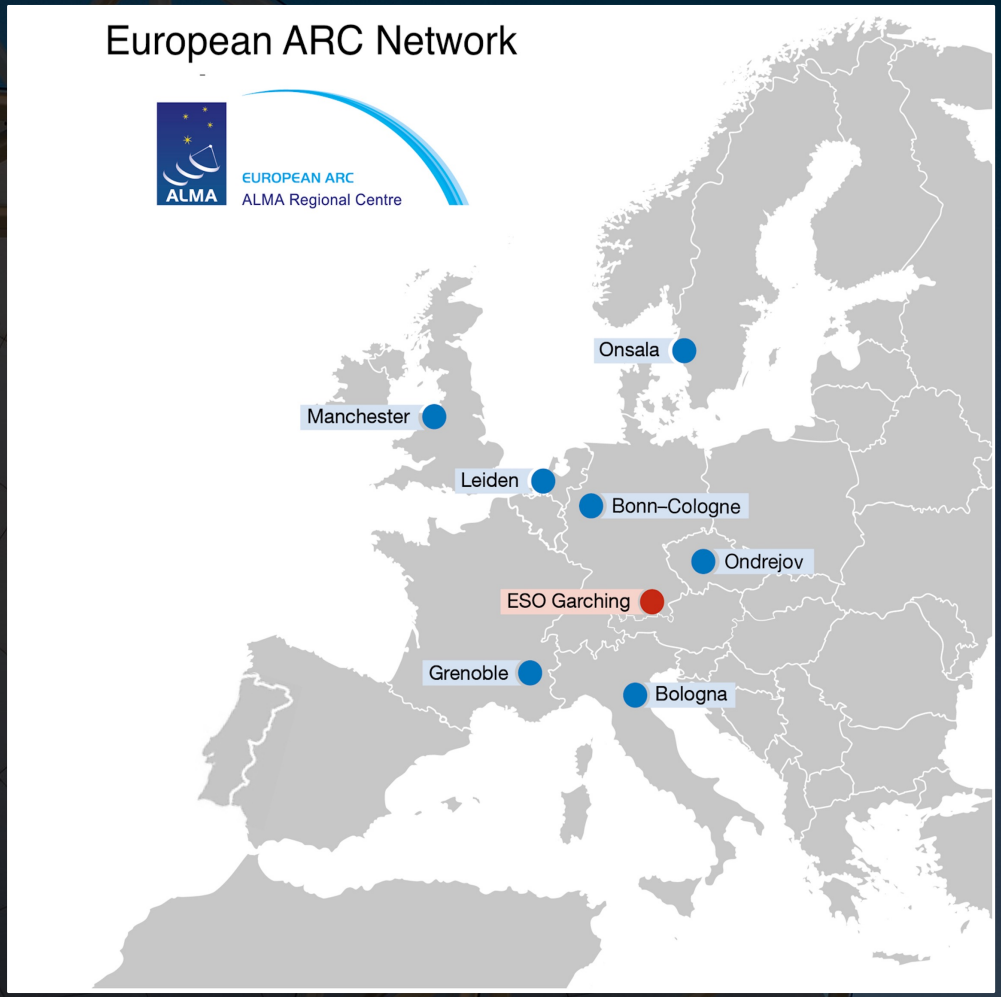
The Joint ALMA Office (JAO) in Chile coordinates all activities.



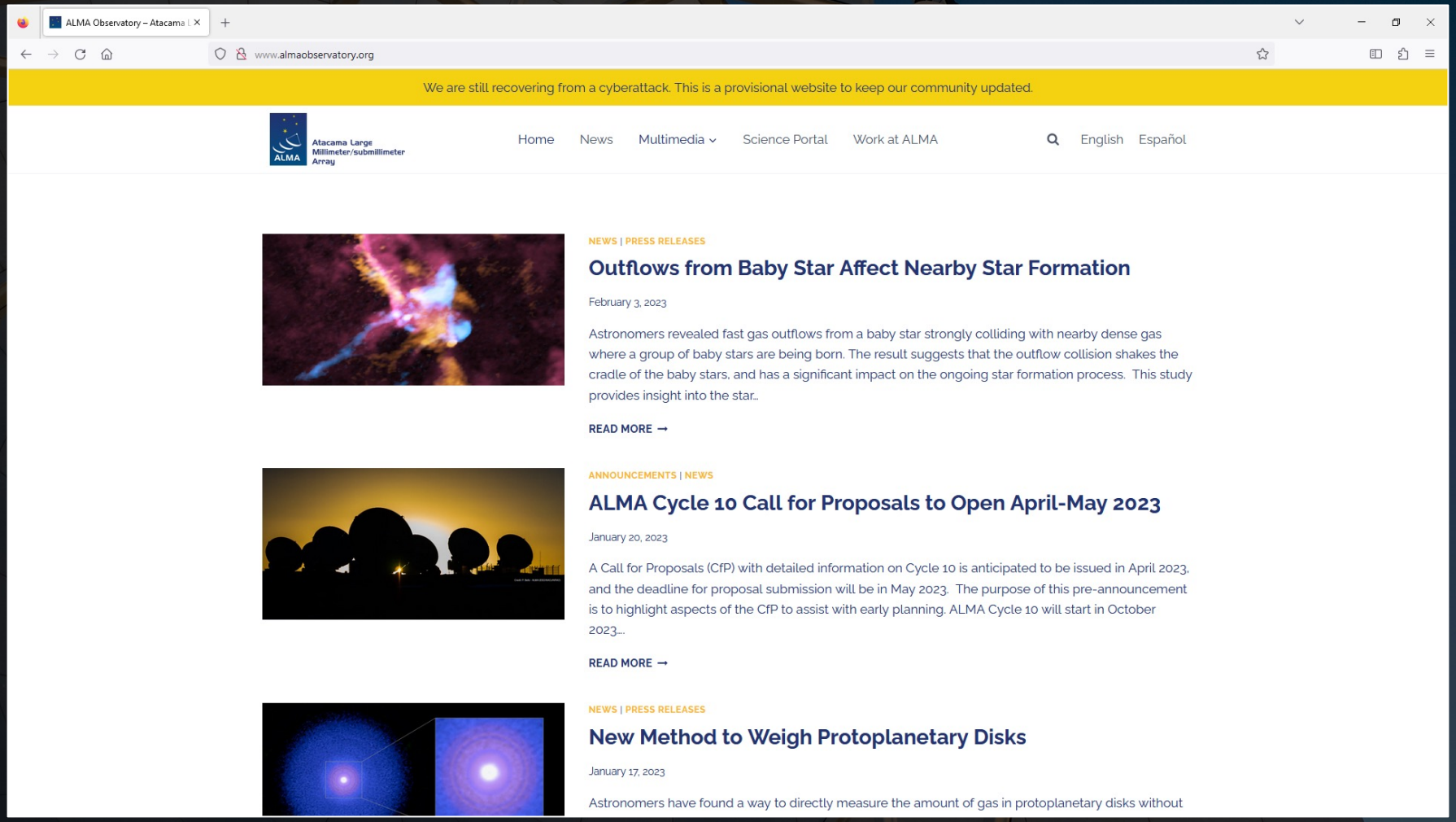
The European Southern Observatory coordinates ALMA activities in Europe.

Multiple ARC Nodes provide local user support. Staff at these nodes also participate in other support activities.

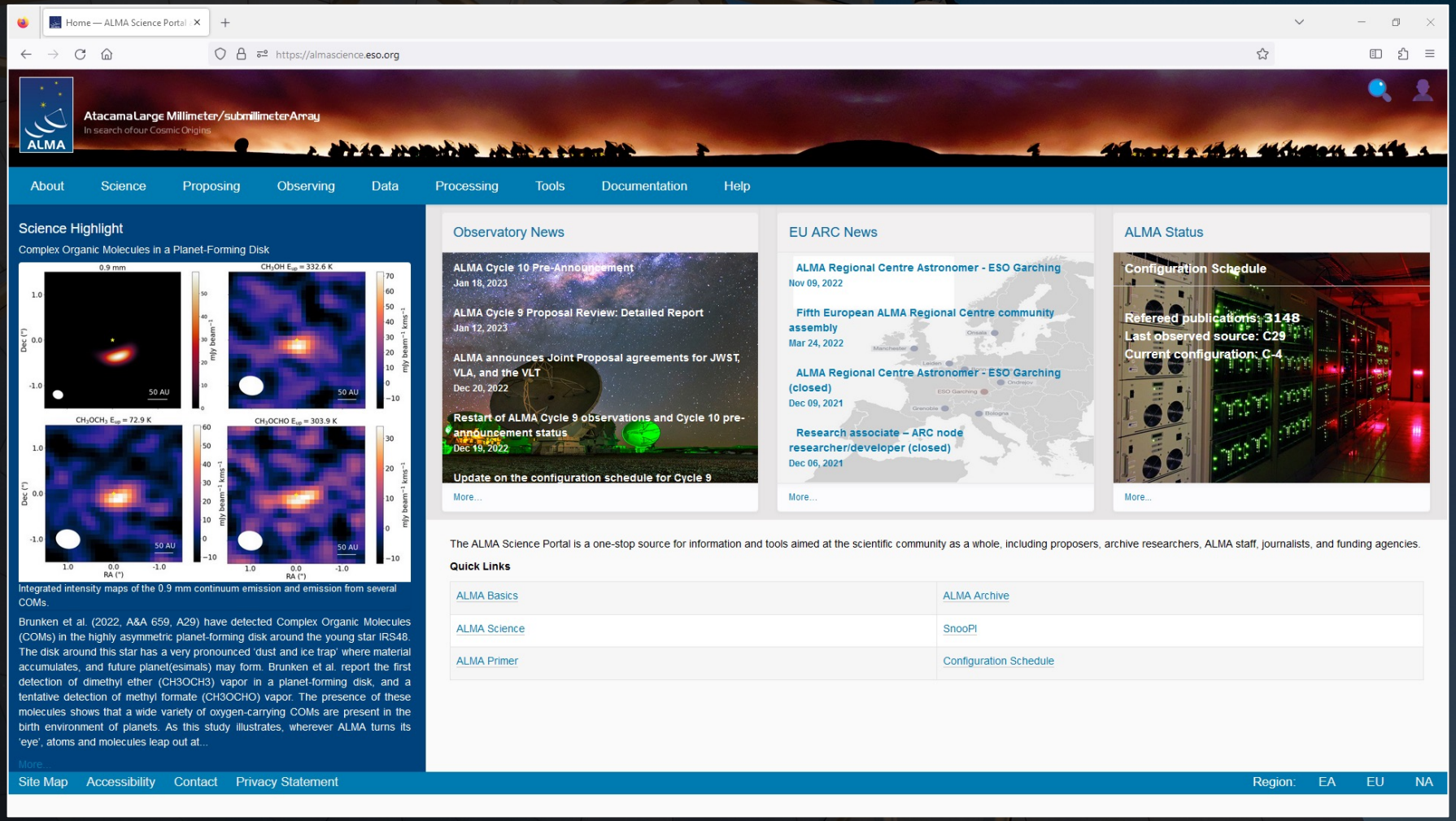
The University of Manchester hosts the ARC Node for the United Kingdom.



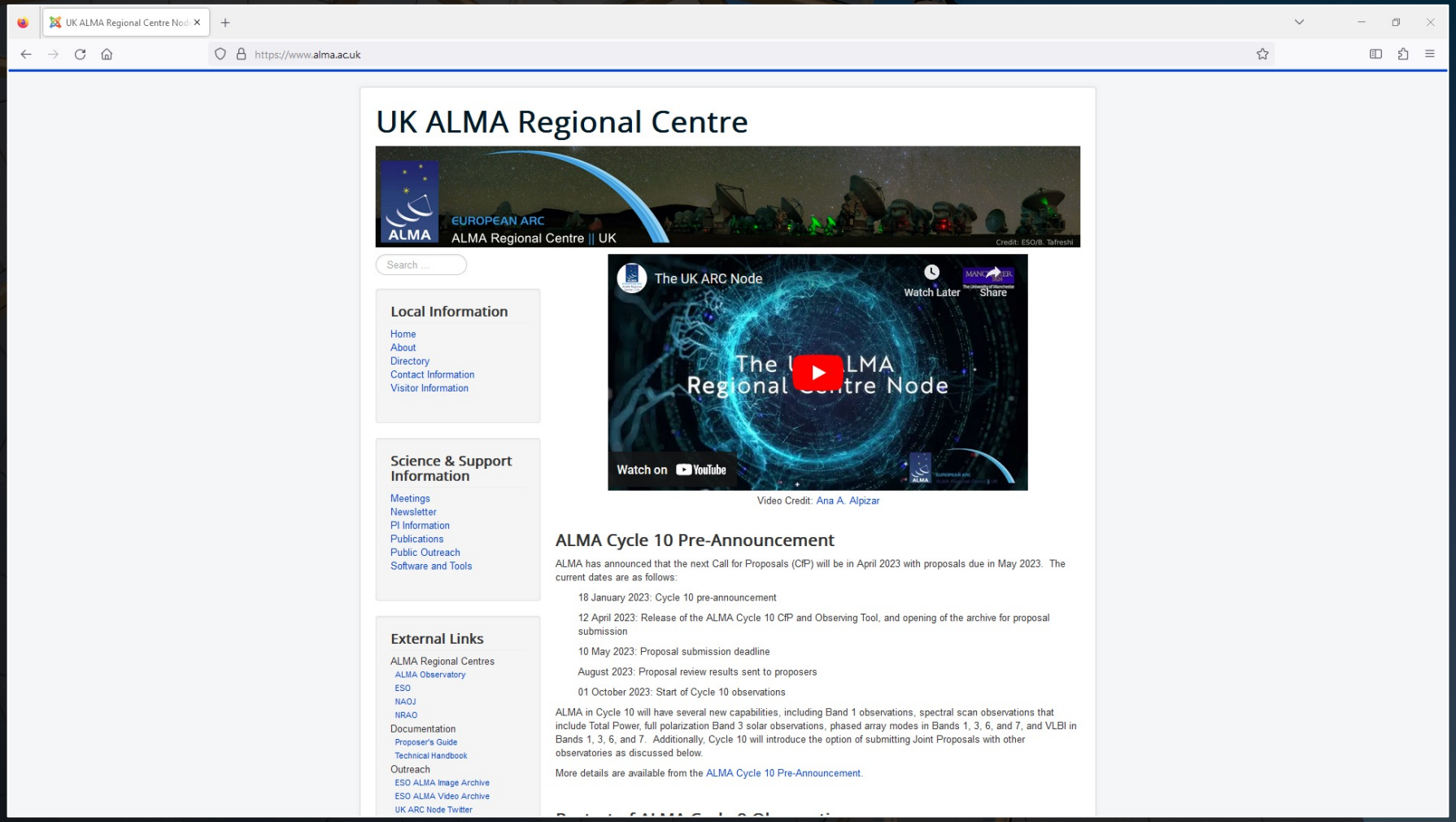
The ALMA website for the general public is at http://www.almaobservatory.org.



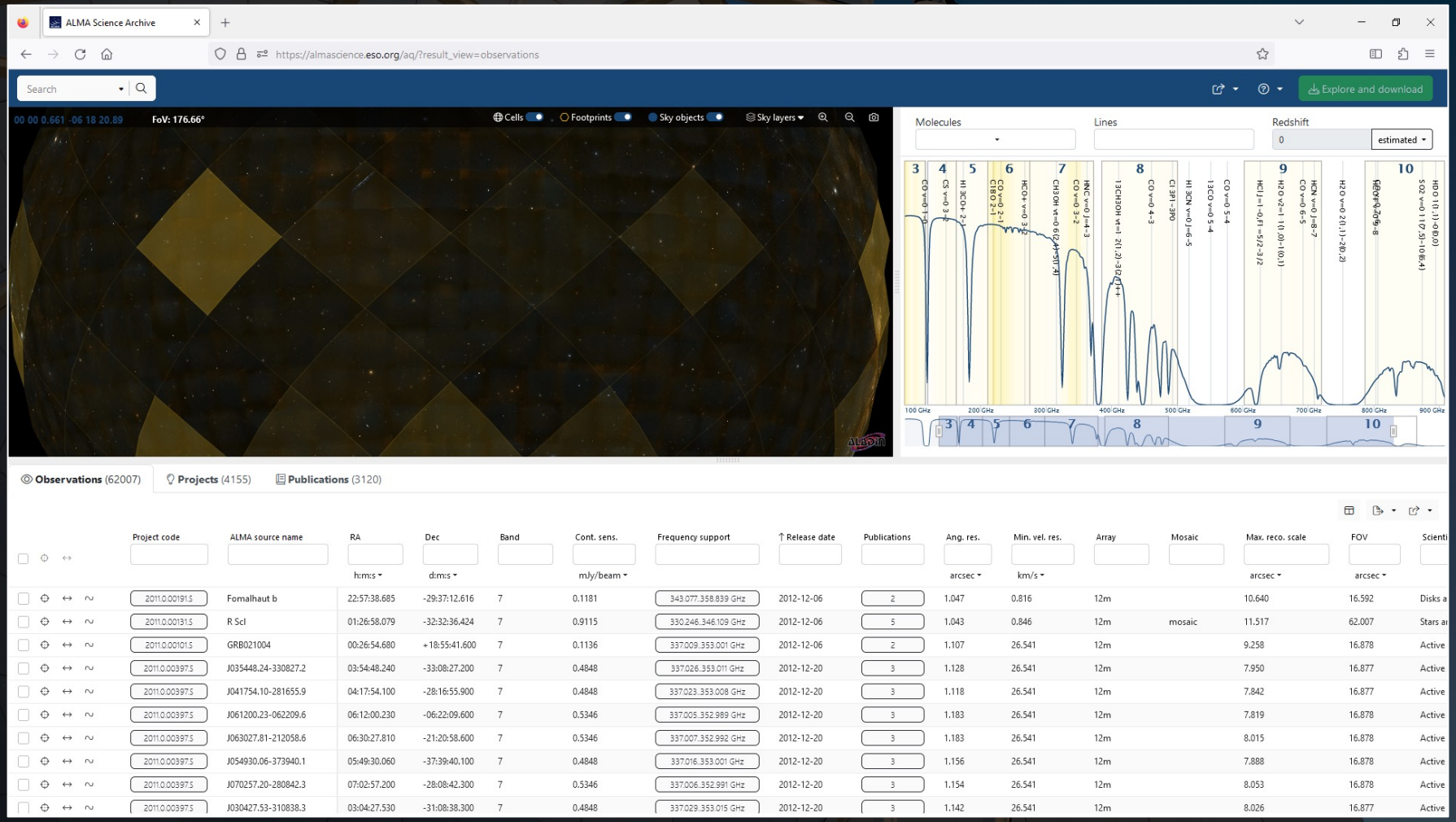
Each ARC has a professional astronomer page. The ESO ARC webpage is at https://almascience.eso.org.



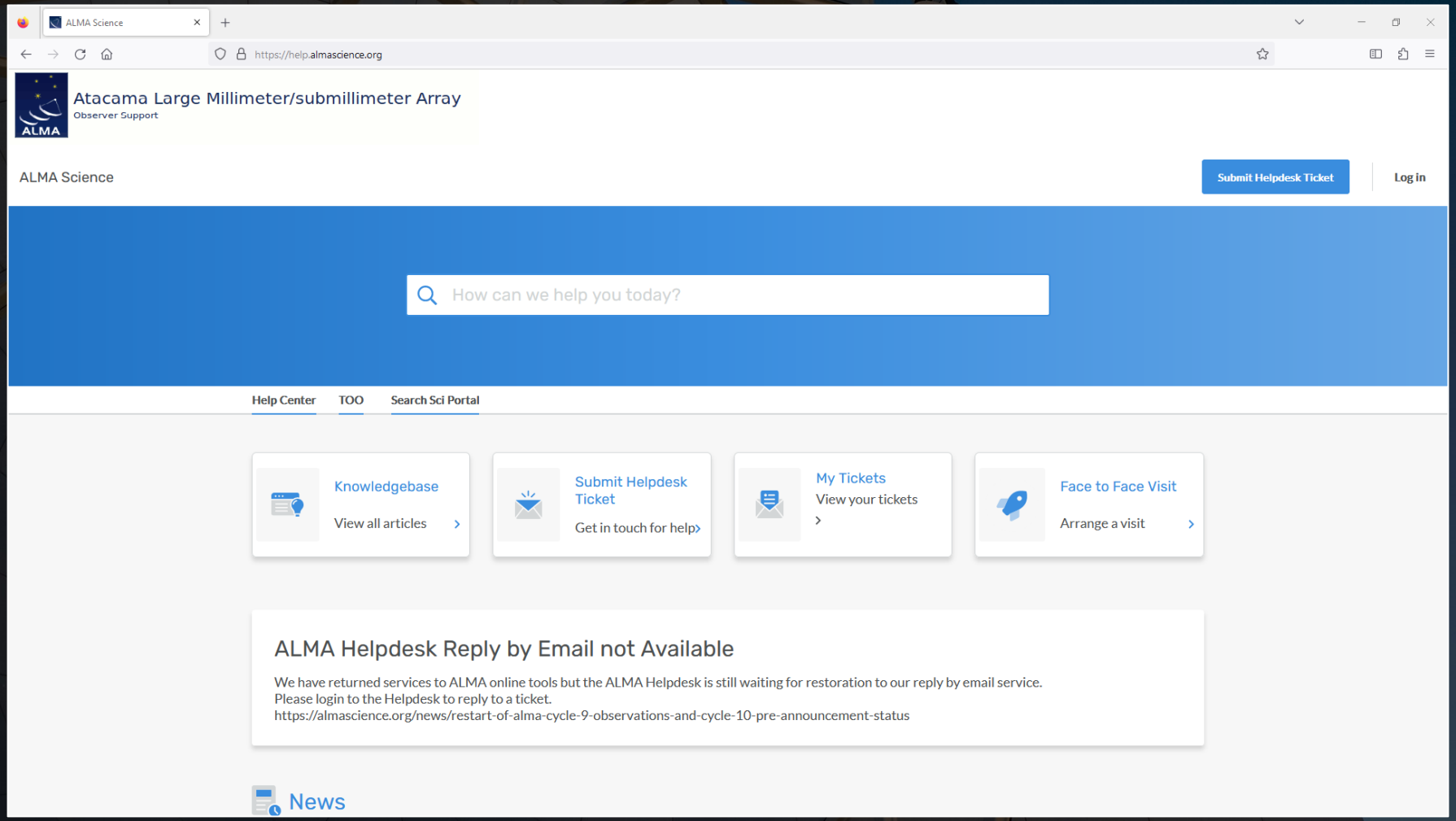
The UK ARC Node has a website at https://www.alma.ac.uk that provides news and information for UK ALMA users.



Data can be downloaded from the ALMA Science Archive at https://almascience.eso.org/aq.

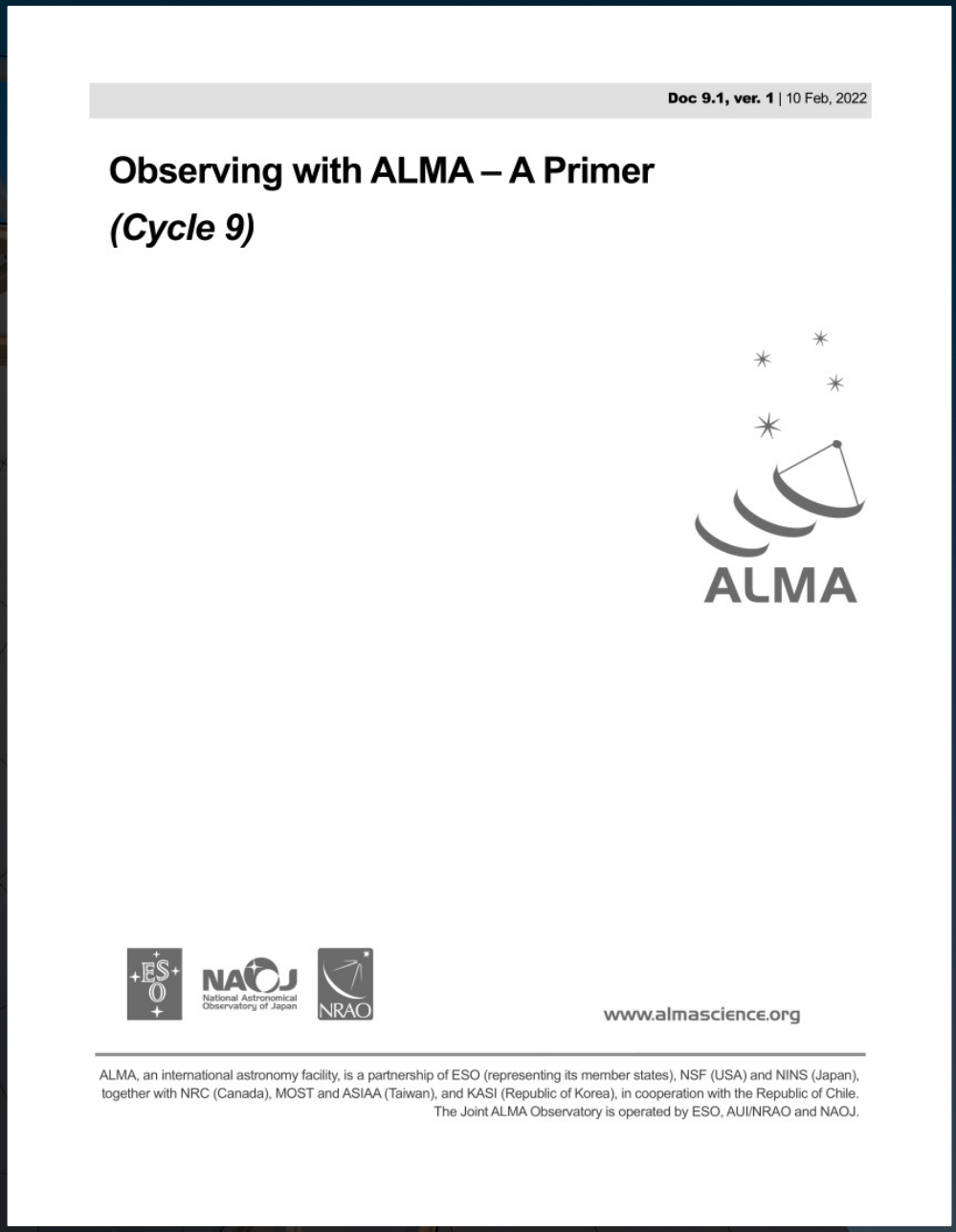


The best way to communicate with ALMA staff (including the UK ARC Node) is to use the ALMA Helpdesk at https://help.almascience.org.



The documentation website (https://almascience.eso.org/documents-and-tools) has three documents that are very useful references:

- Observing with ALMA – A Primer
- ALMA Proposer's Guide
- ALMA Technical Handbook



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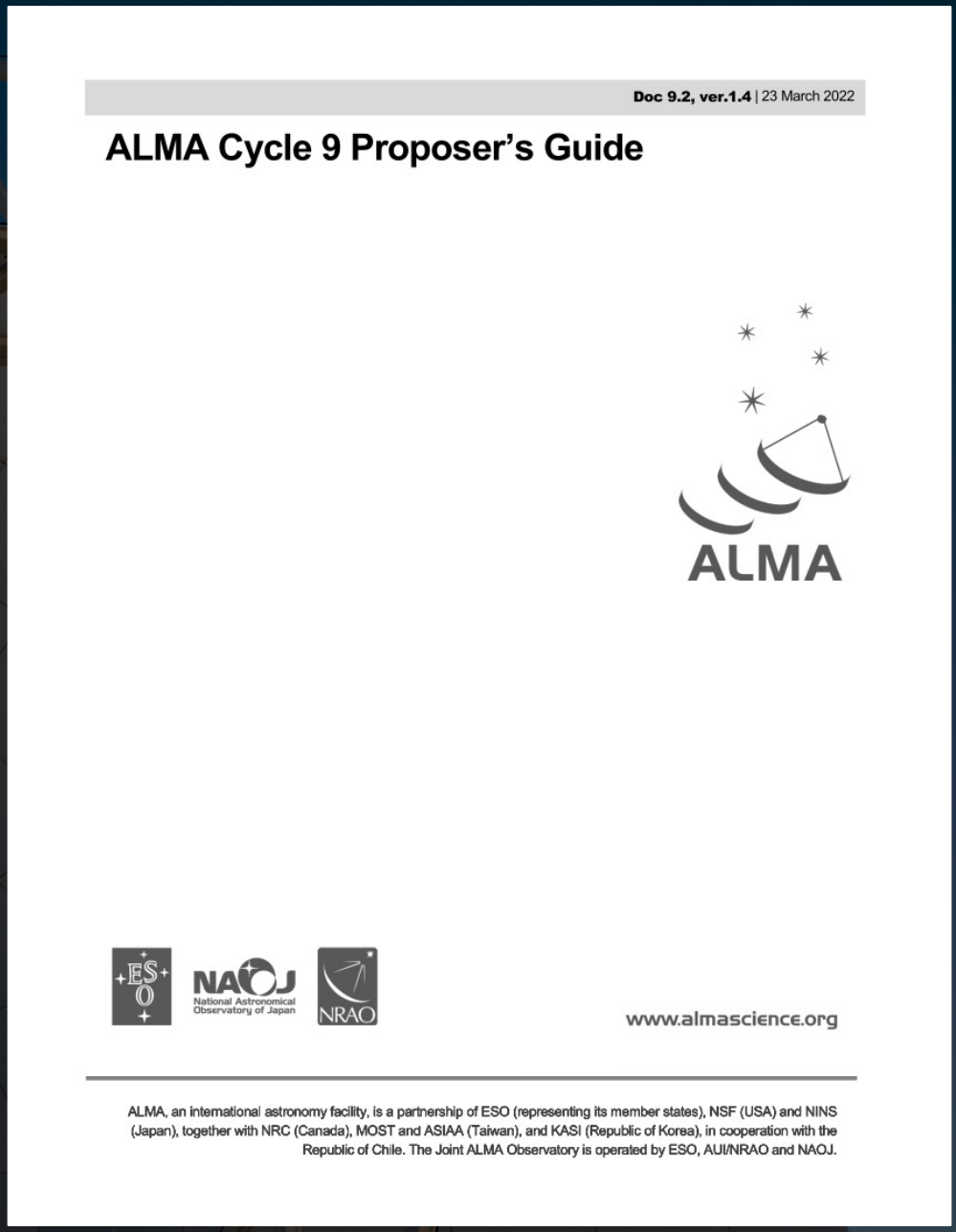

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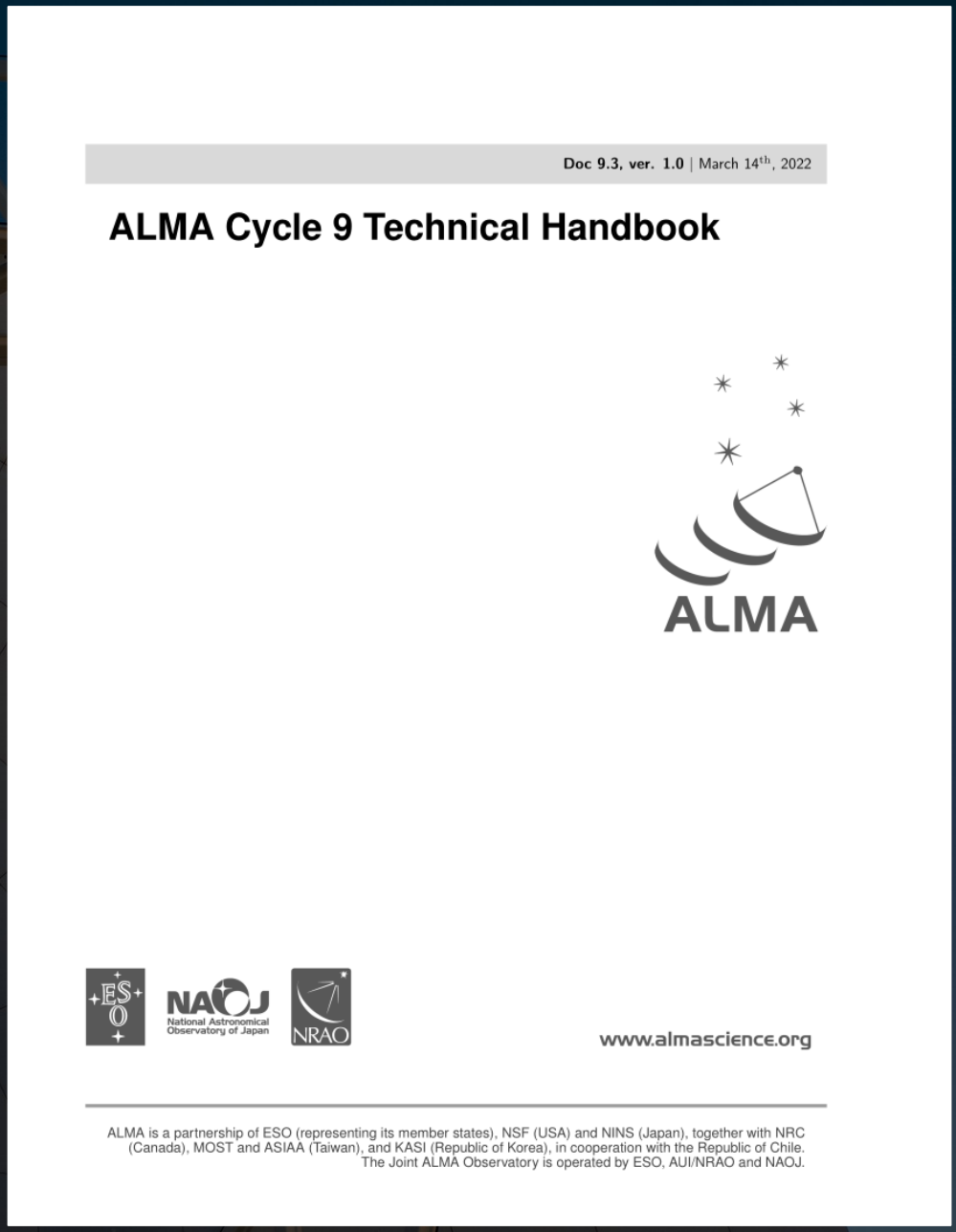
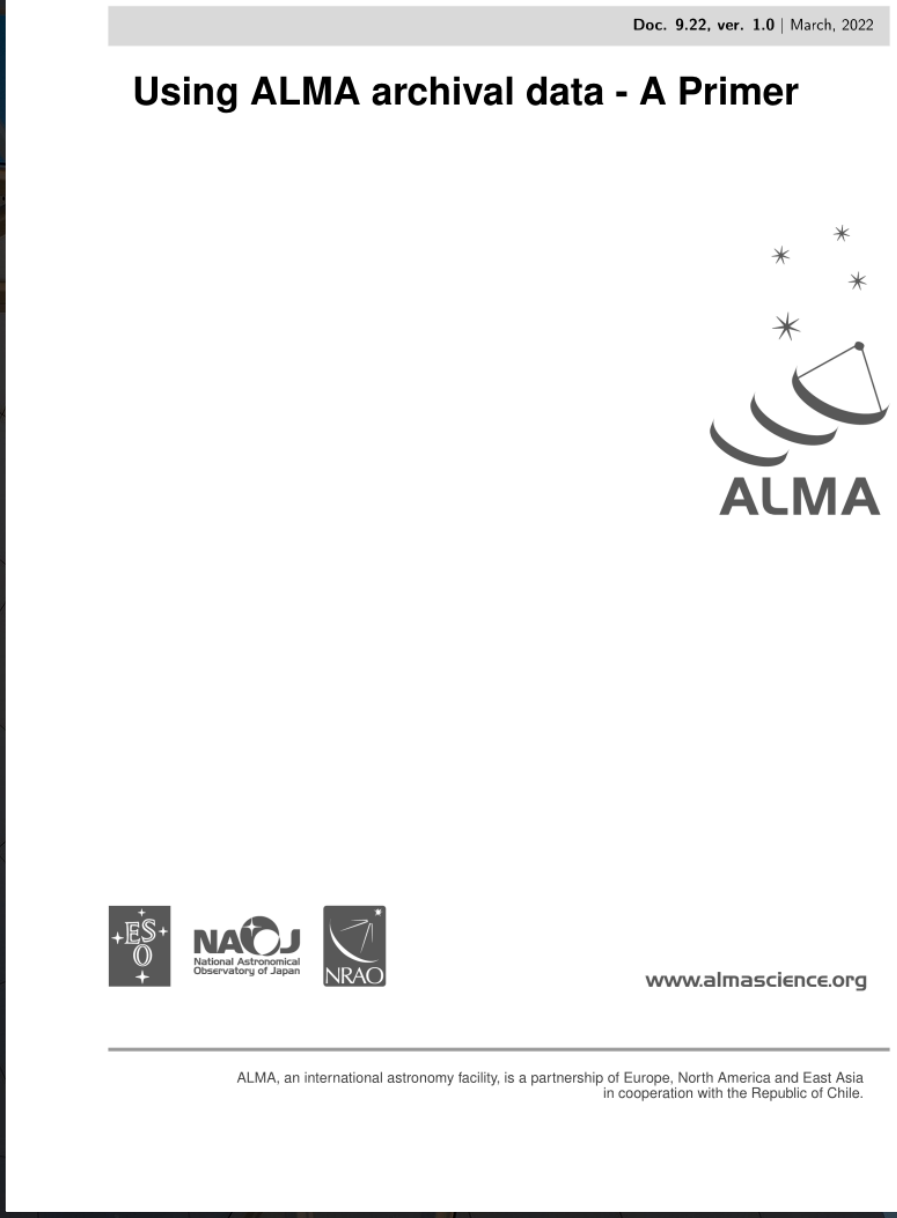


I have also worked on a document on using the ALMA Archive that is also available from https://almascience.eso.org/documents-and-tools.



Doc. 9.22, ver. 1.0 | March, 2022

Using ALMA archival data - A Primer

ALMA

ESO NAOJ National Astronomical Observatory of Japan NRAO

www.almascience.org

ALMA, an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile.

Cycle 9 cyberattack

On 29 October 2022, ALMA suffered a cyberattack. This did not affect any astronomical data, but observing and several other activities halted as a precaution.

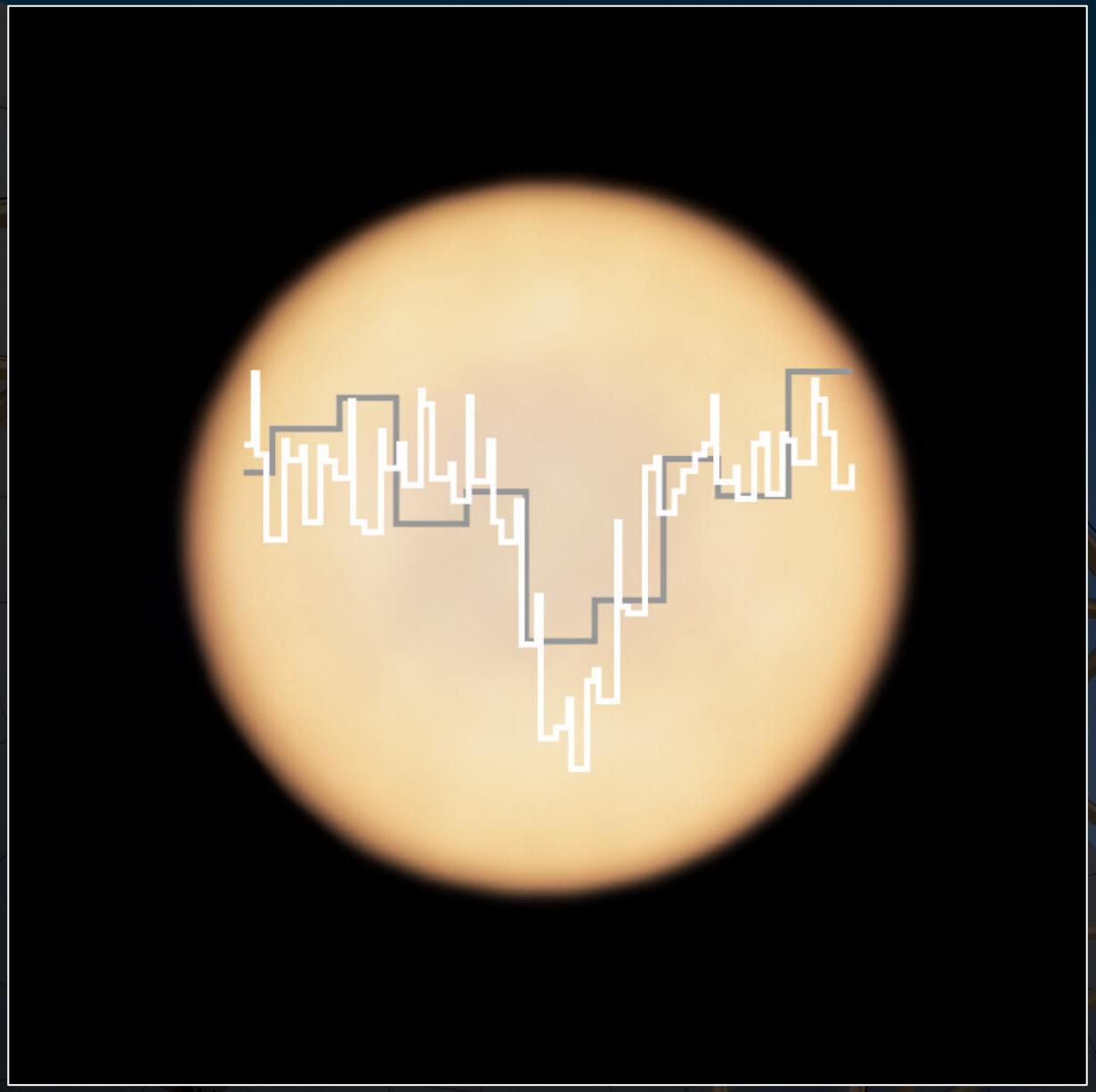
On 19 December 2022, ALMA restarted observations. By this point in time, multiple other systems had also been restarted, and astronomers started getting data again.

However, this had a couple of additional effects:

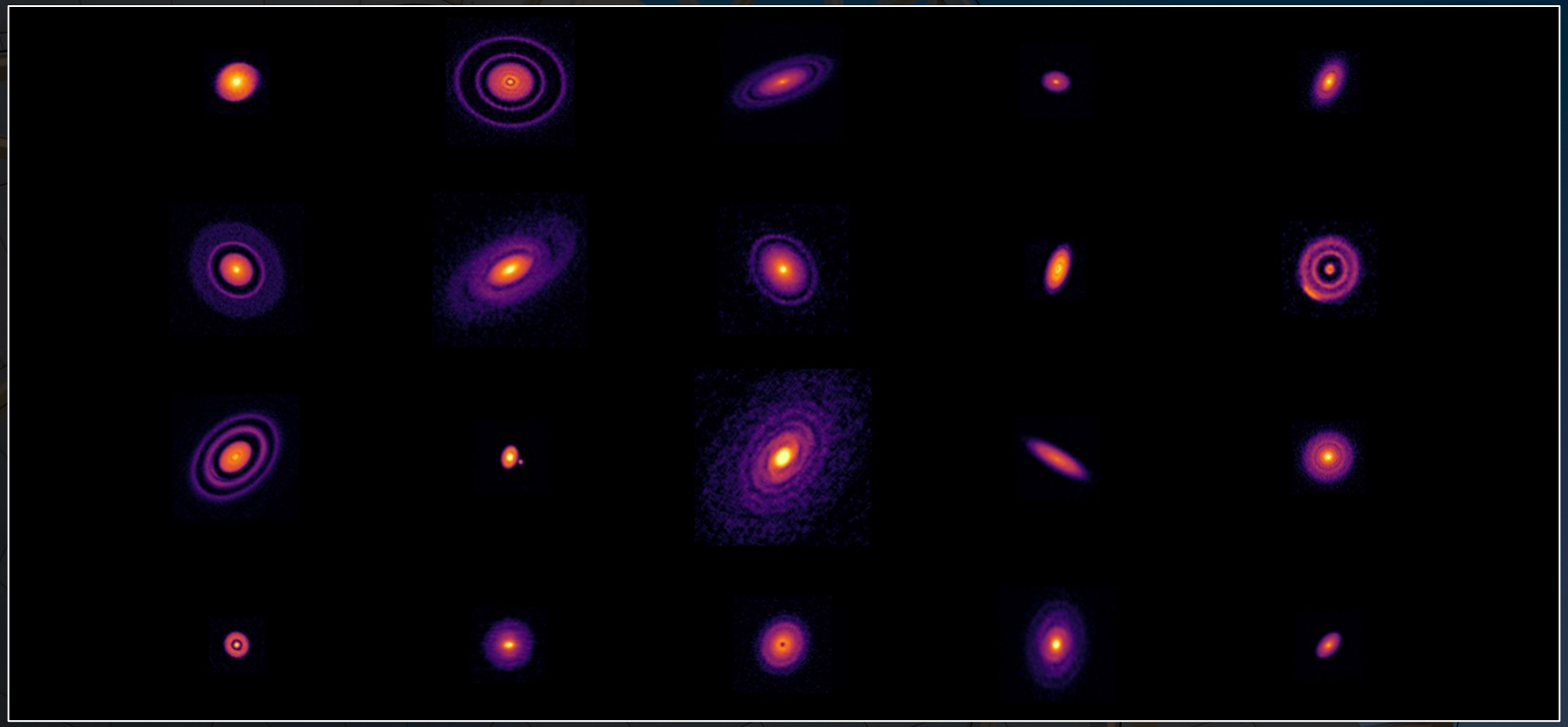
- Most observations with the most compact 12m configurations were not performed.
- The proposal schedule for Cycle 10 was pushed back.

Cycle 10 schedule

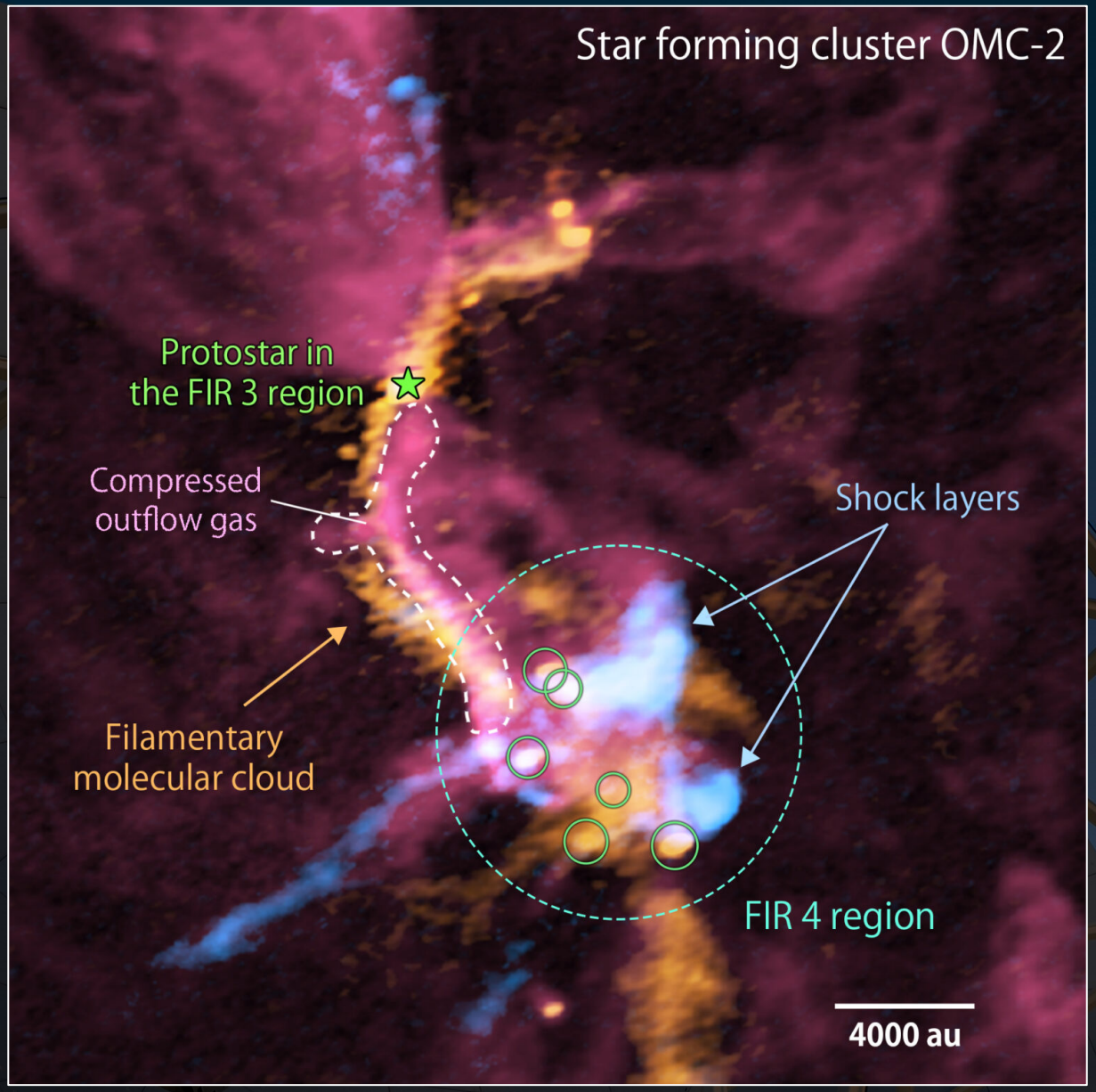
20 Jan 2023	Cycle 10 pre-announcement
12 April	Call for proposals
10 May	Proposals due
May-June	Distributed peer review process
mid-August	Grades for proposals are announced
September	Phase 2 of proposal submission (review of the Scheduling Blocks)
30 September	End of Cycle 9 observations
01 October	Start of observations for Cycle 10



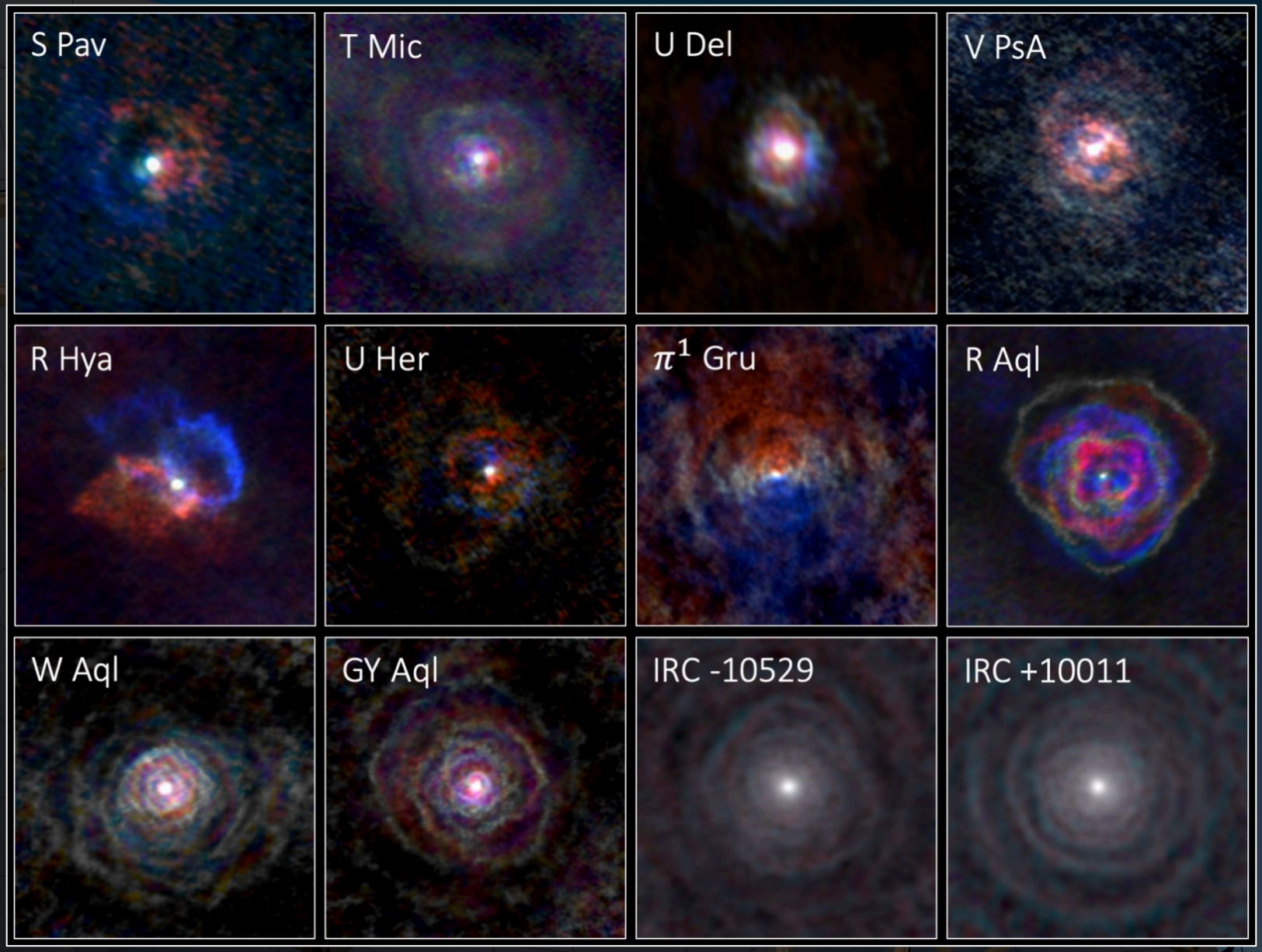
(Credit: ALMA (ESO/NAOJ/NRAO), Greaves et al. & JCMT (East Asian Observatory))



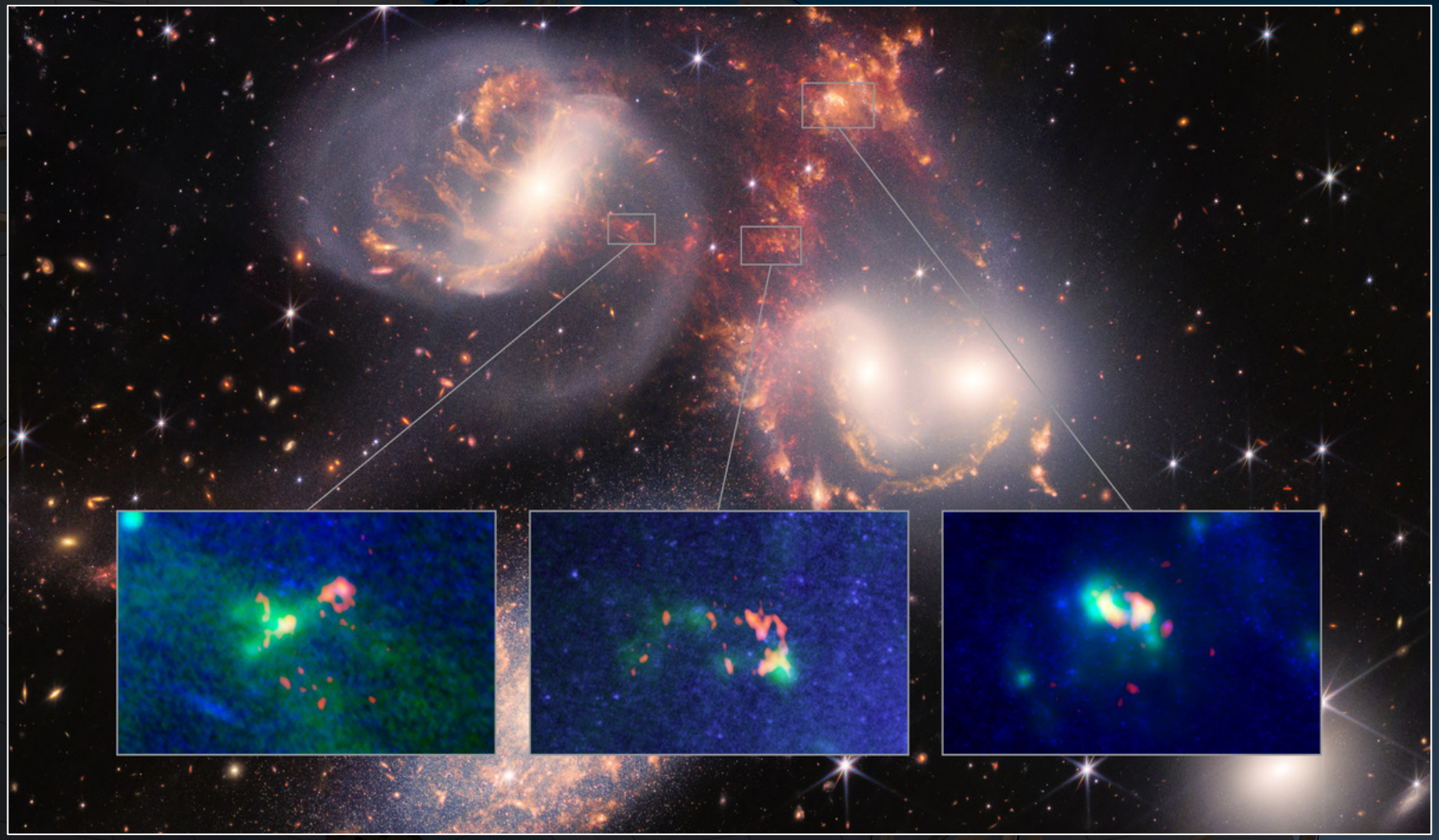
(Credit: ALMA (ESO/NAOJ/NRAO), S. Andrews et al.; N. Lira)



(Credit: ALMA (ESO/NAOJ/NRAO), A. Sato et al.)

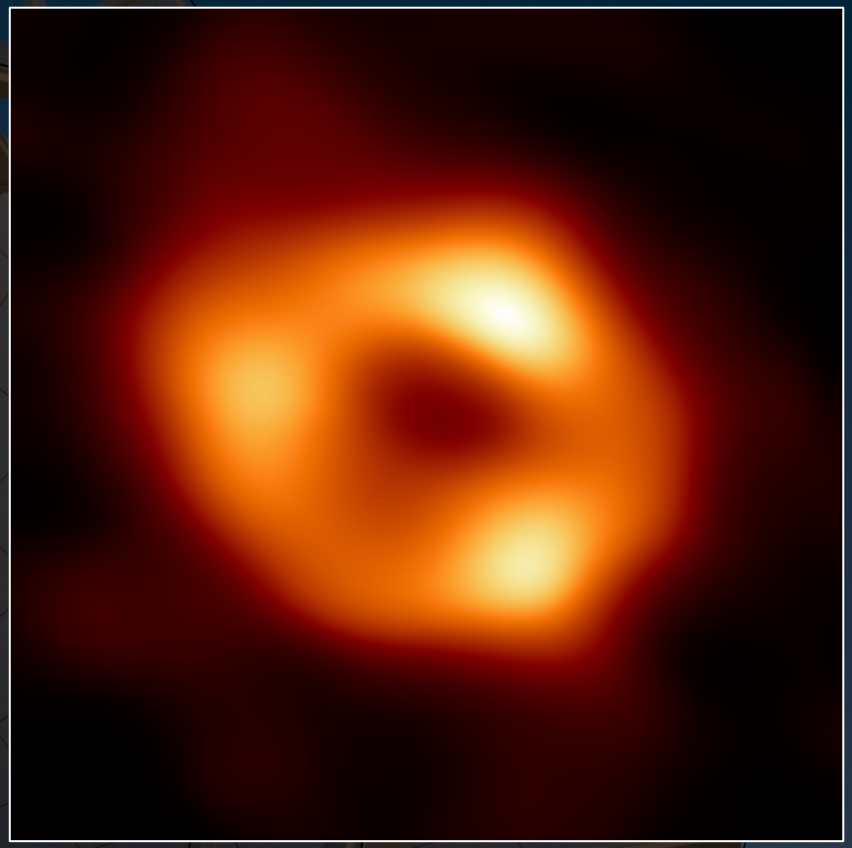


(Credit: L. Decin – ESO – ALMA)

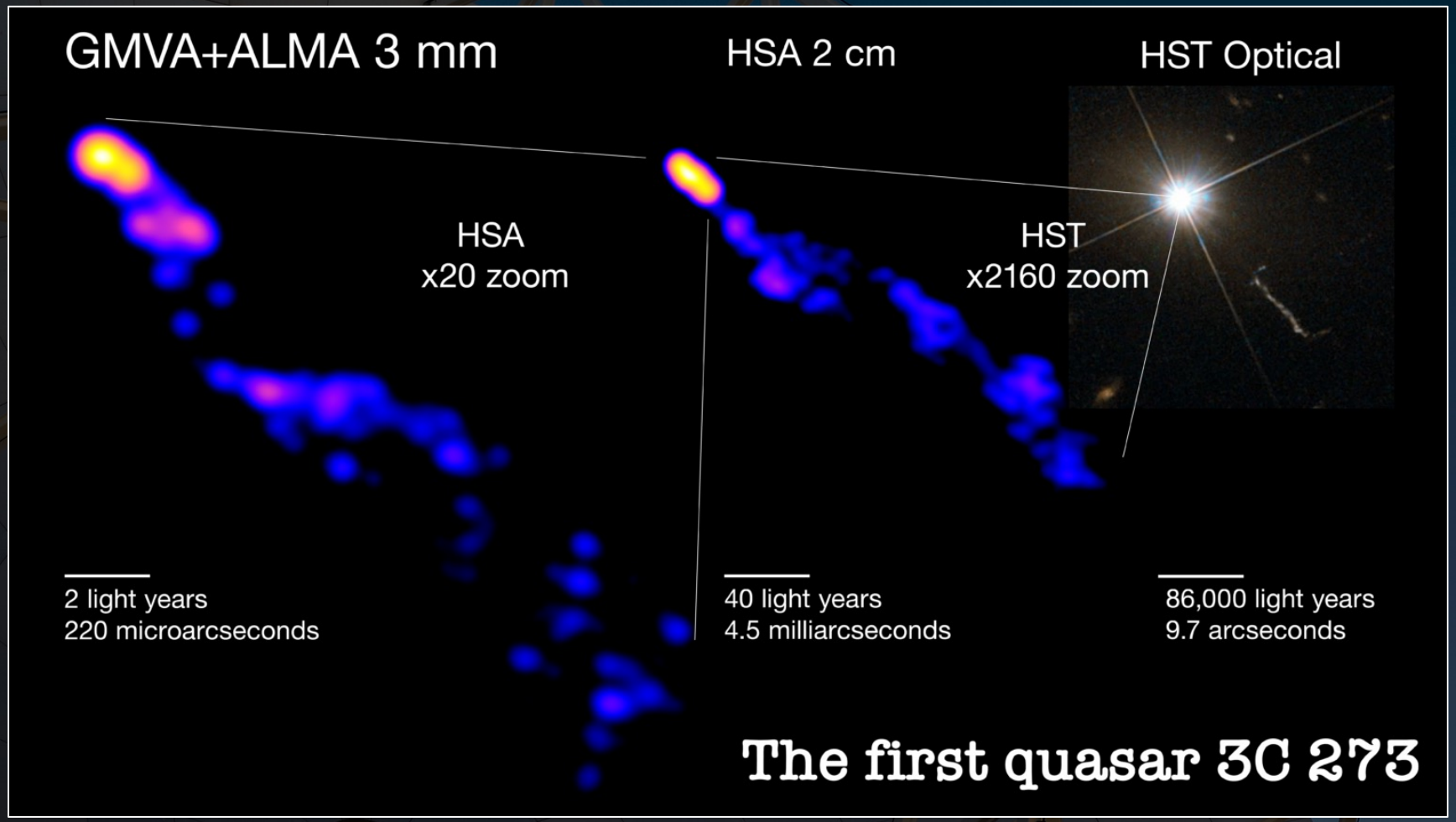


(Credit: ALMA (ESO/NAOJ/NRAO)/JWST/ P. Appleton (Caltech), B.Saxton (NRAO/AUI/NSF))

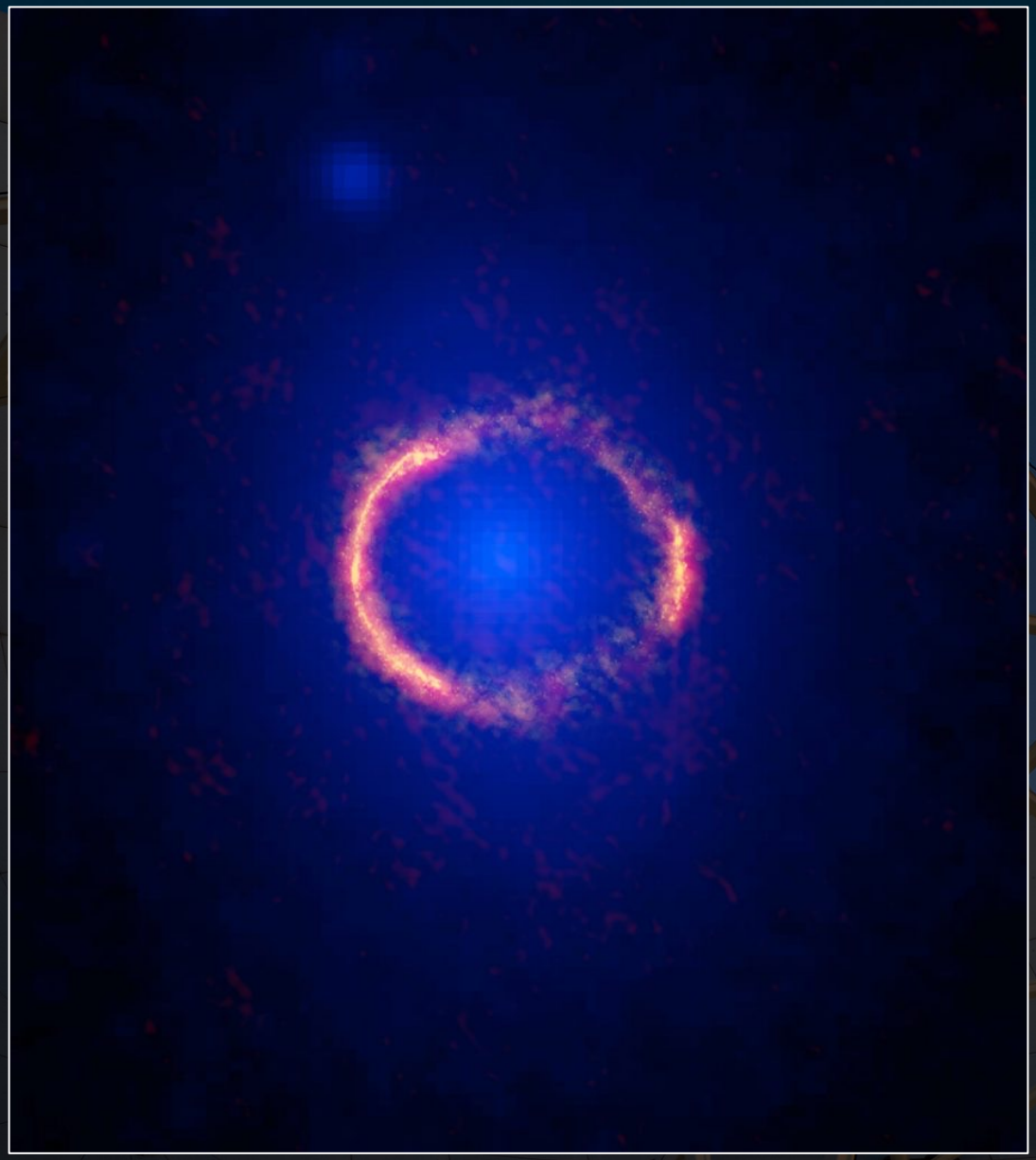
(Credit: EHT Collaboration)



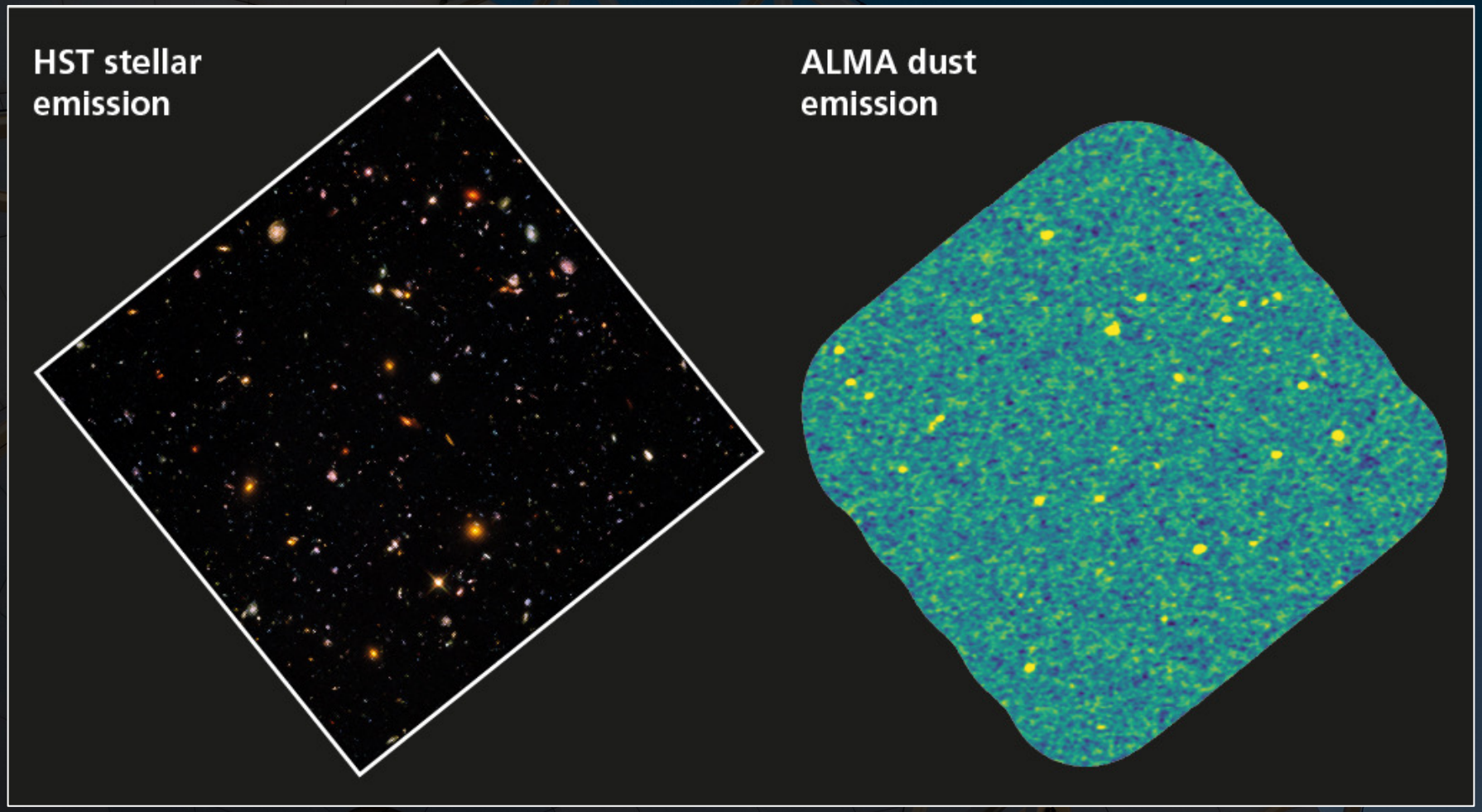
(Credit: EHT Collaboration)



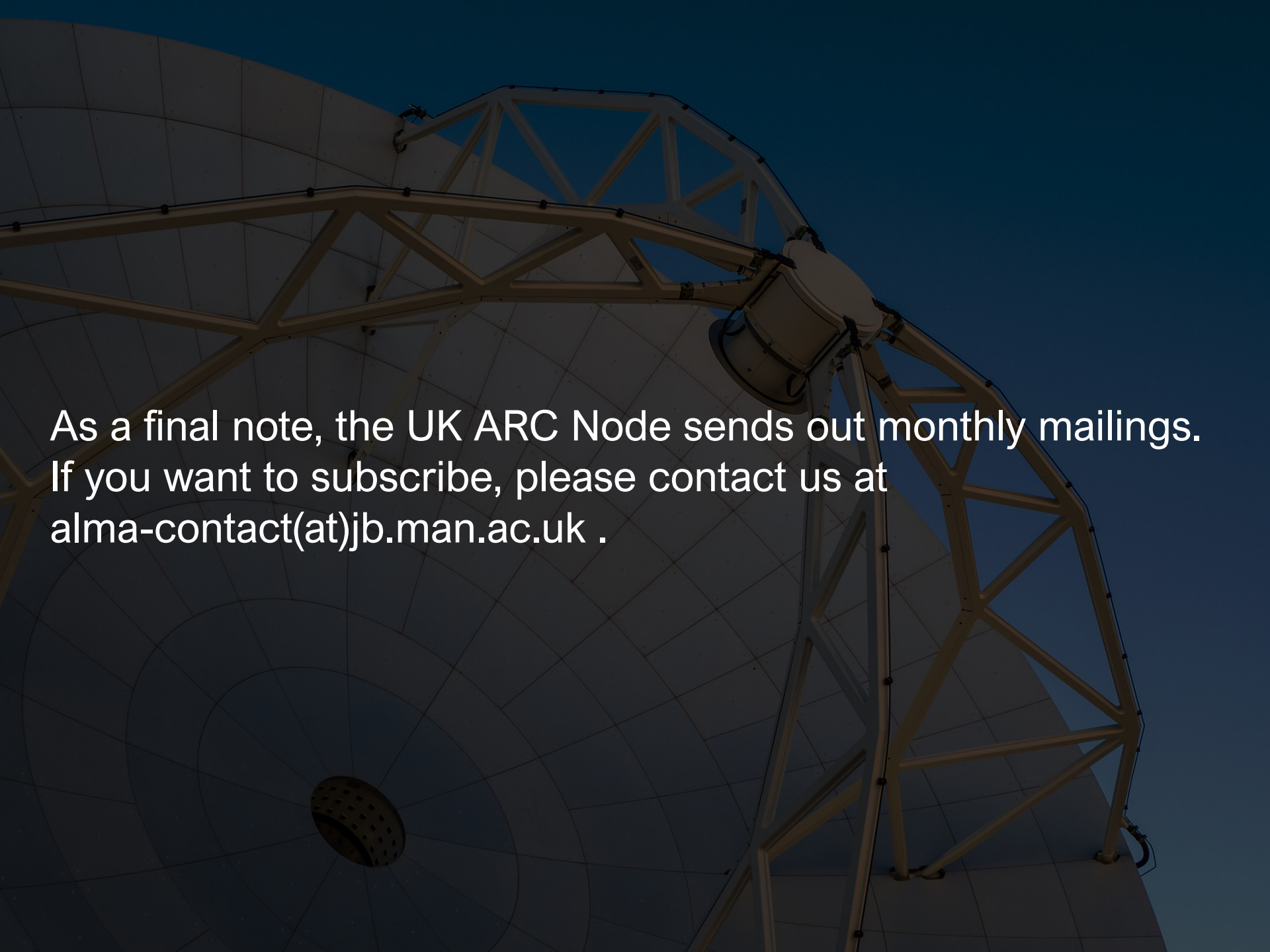
(Credits: Hiroki Okino and Kazunori Akiyama; GMVA+ALMA and HSA images: Okino et al.; HST Image: ESA/Hubble & NASA)



(Credit: ALMA (NRAO/ESO/NAOJ); B. Saxton NRAO/AUI/NSF; NASA/ESA Hubble, T. Hunter (NRAO))



(Credit: STScI, Gonzalez-Lopez et al, ALMA (ESO/NAOJ/NRAO))



As a final note, the UK ARC Node sends out monthly mailings. If you want to subscribe, please contact us at alma-contact(at)jb.man.ac.uk .