

# An Introduction to ALMA

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A large, white, parabolic radio telescope dish is shown against a dark blue sky. The dish is supported by a complex metal truss structure. The text is overlaid on the left side of the image.

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.

A large, white, segmented radio telescope dish is shown against a dark blue sky. The dish is supported by a complex metal truss structure. The text is overlaid on the left side of the image.

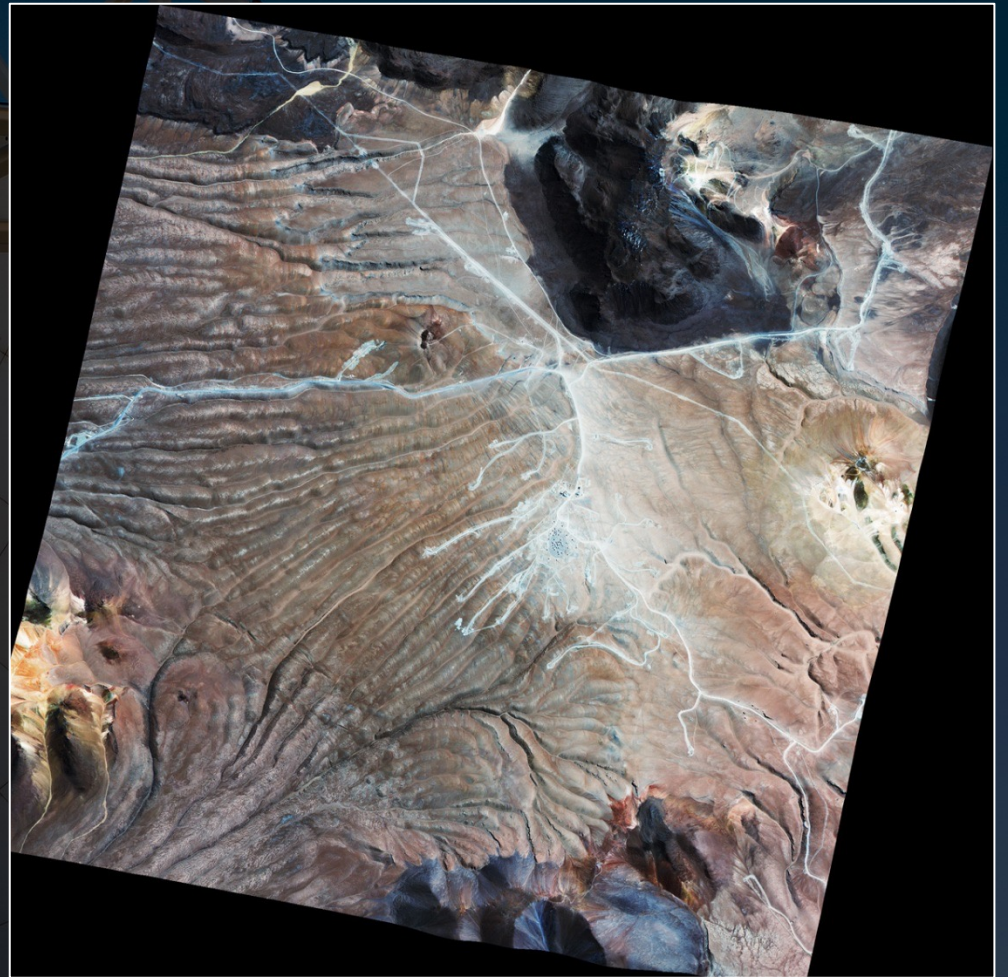
## Some of the science performed with ALMA includes:

- 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 Service, 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))

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

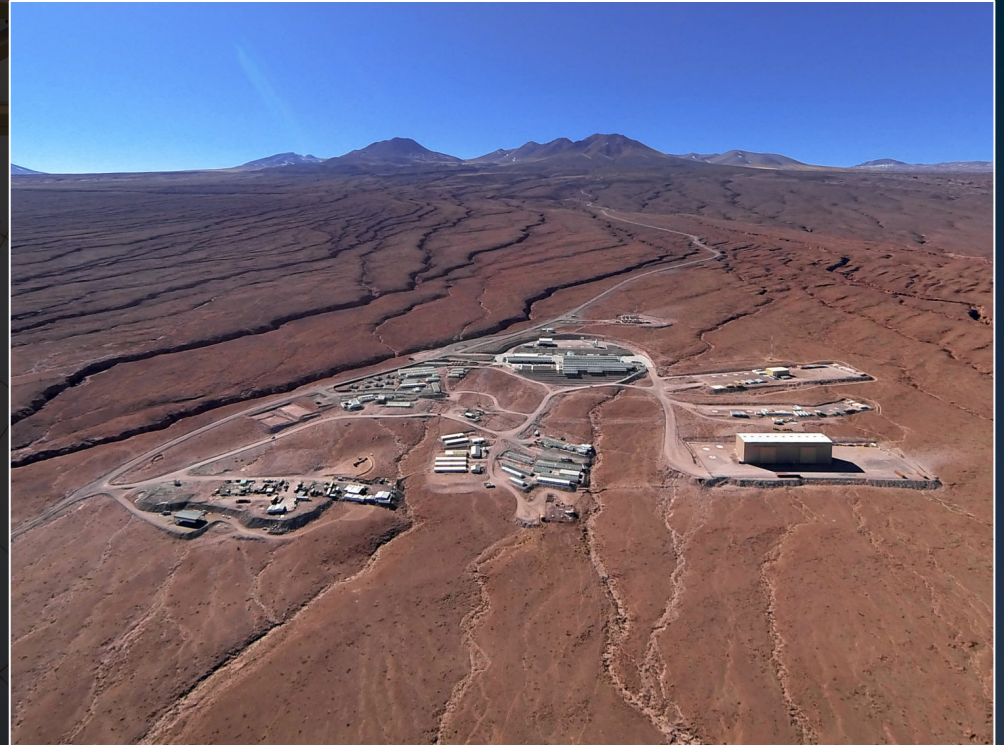
Access to the site is highly restricted, even for people working with the observatory.



(Credit: 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.



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

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(Credit: ESO)

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



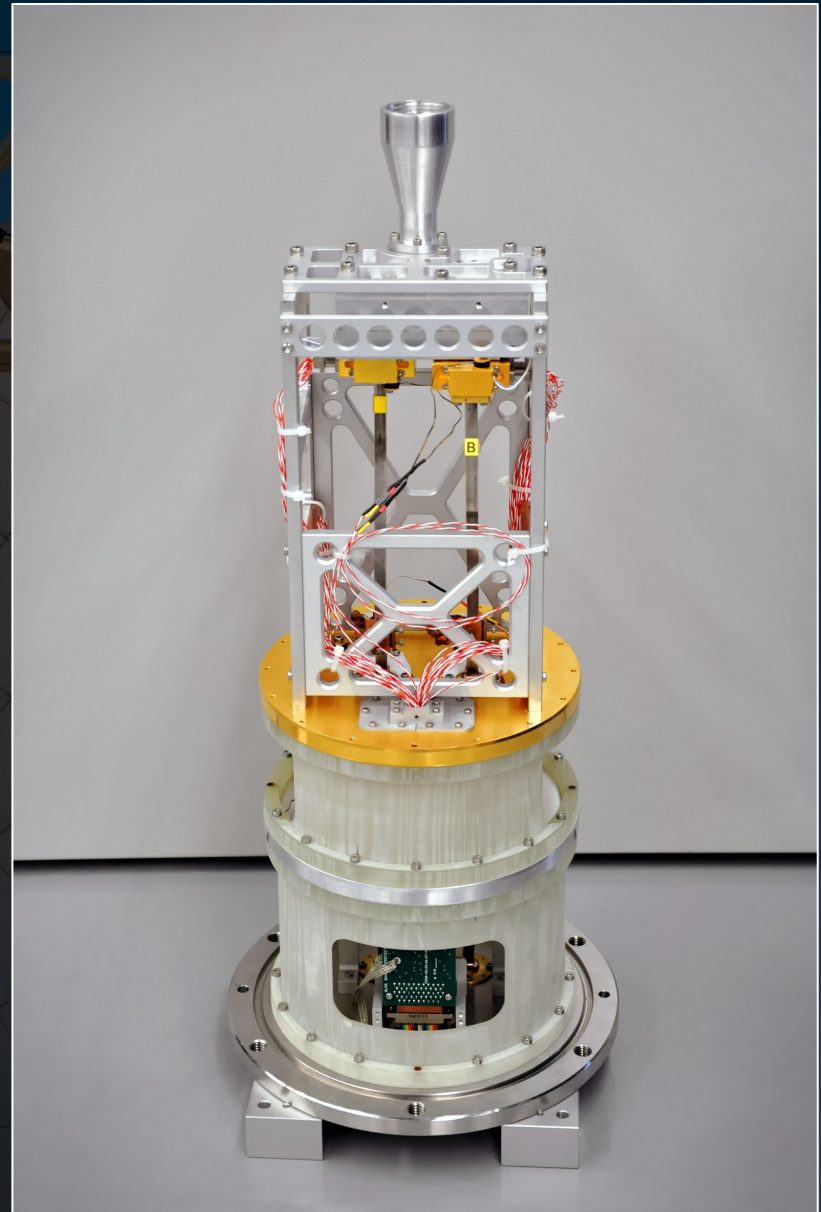
(Credit: ESO & ALMA (ESO/NAOJ/NRAO))



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.

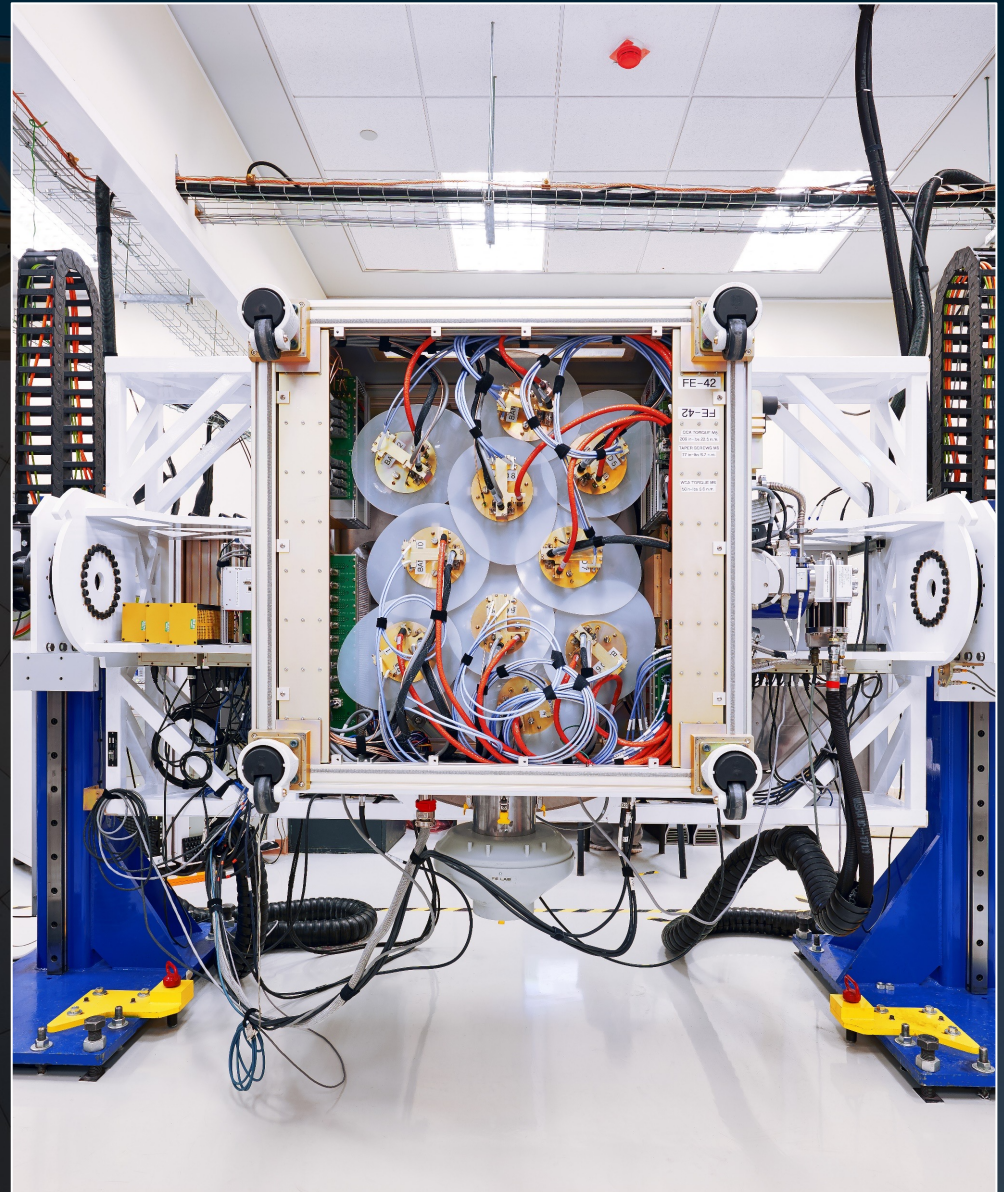


(Credit: ASIAA/NAOJ/ESO/S. Guisard ([www.eso.org/~sguisard](http://www.eso.org/~sguisard)))

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(Credit: Enrico Sacchetti/ESO)

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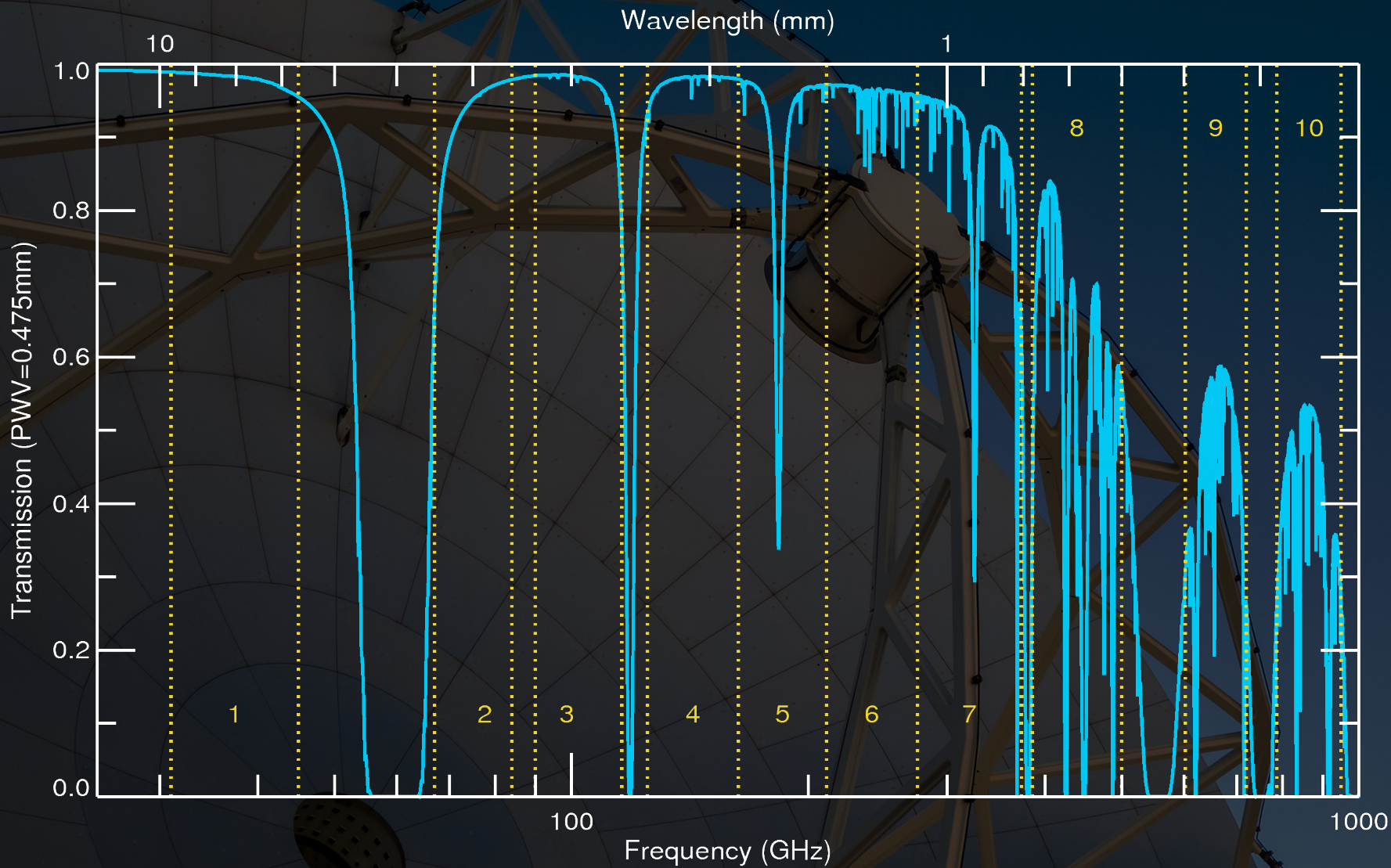
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(Credit: ESO/M. Alexander)

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



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)

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)



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.

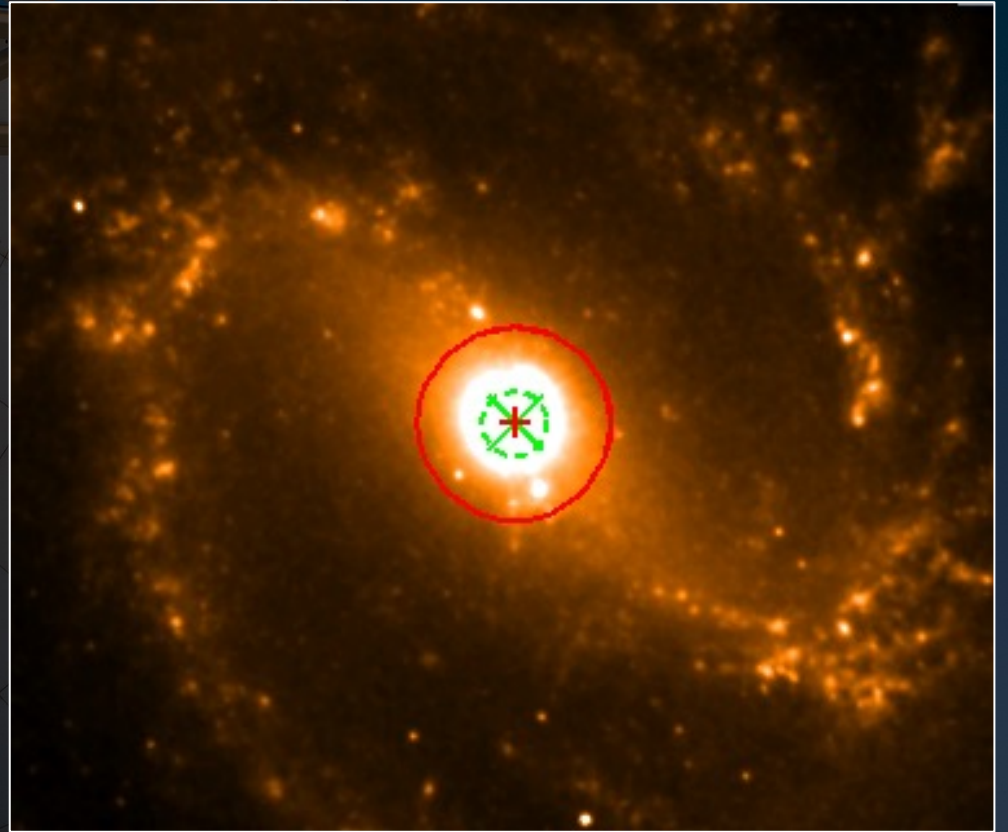


The total power antennas are used to detect large-scale line emission resolved out by both the 12m and ACA arrays. (Continuum-imaging capabilities may be added in the future.)



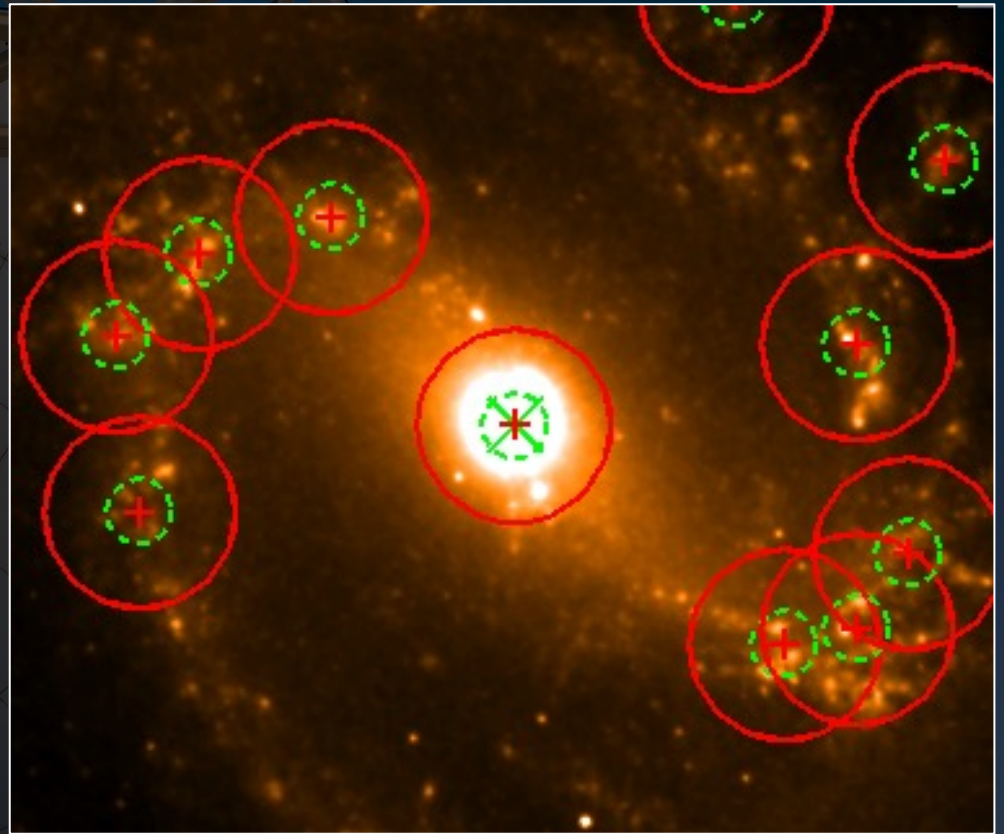
The most basic field that can be imaged by ALMA is a single pointing.

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



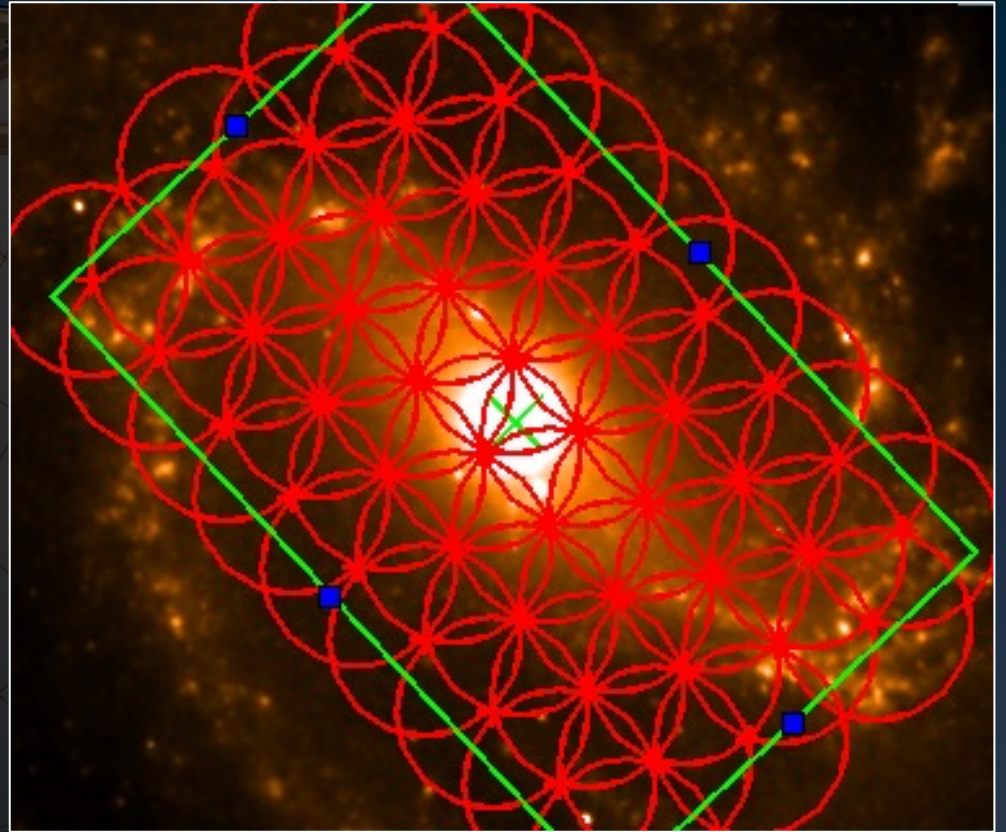
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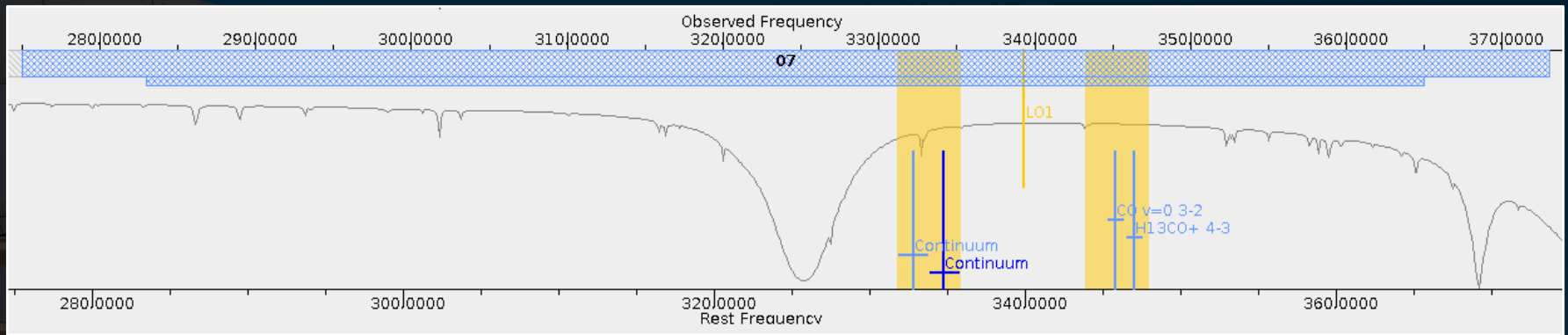
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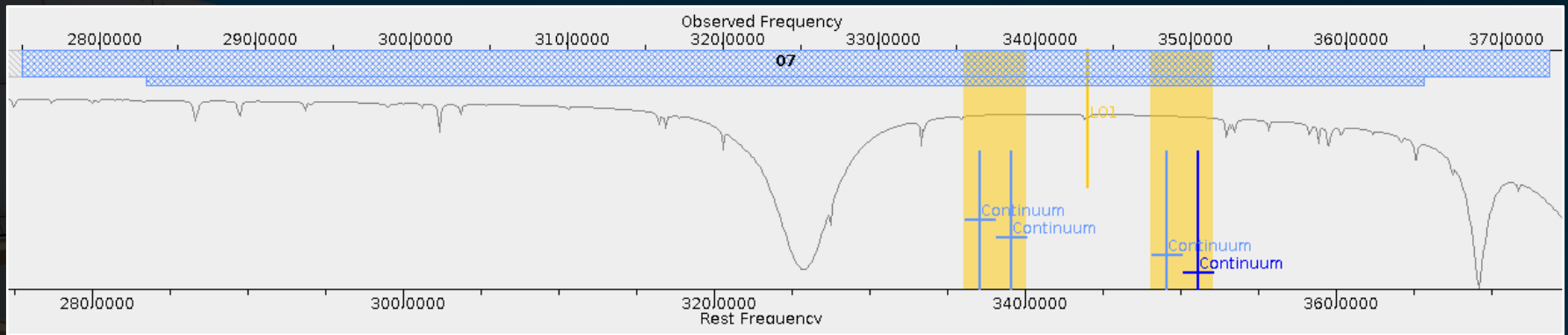


ALMA currently offers three types of spectral set-ups.

- 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).

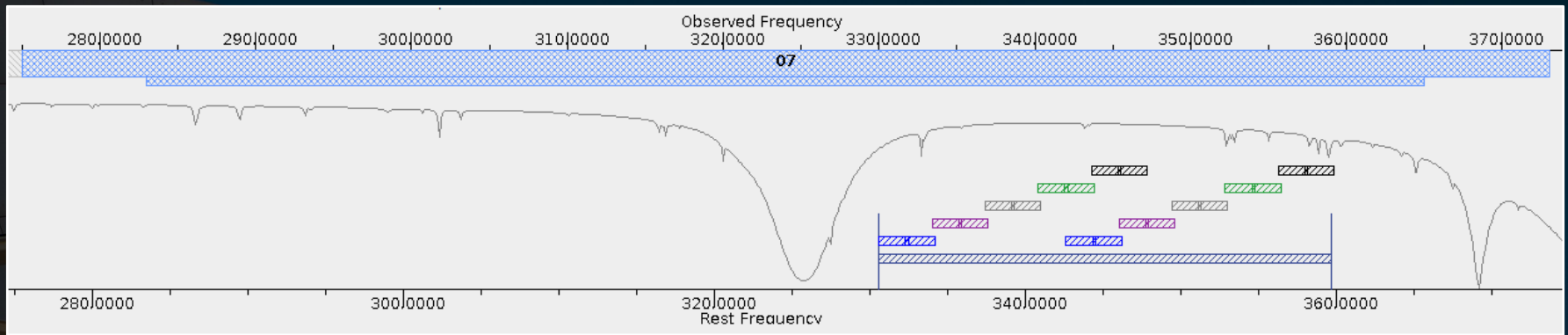


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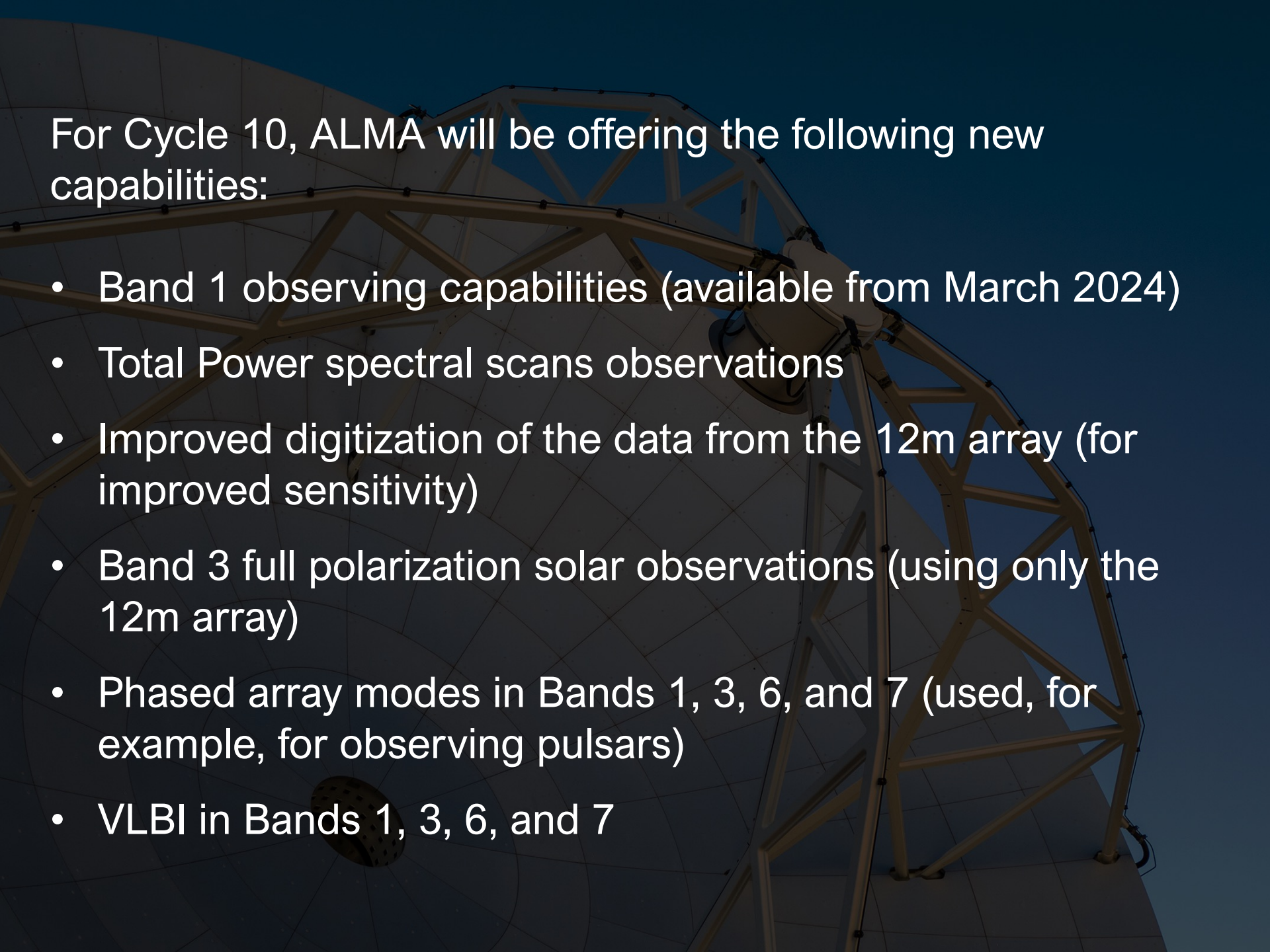
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A large, white, parabolic radio telescope dish is shown against a dark blue sky. The dish is supported by a complex metal truss structure. A smaller, circular secondary dish is visible on the main dish's surface. The overall scene is dimly lit, suggesting dusk or dawn.

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

A large, complex metal structure of an ALMA antenna, featuring a grid of beams and a central feed horn, set against a dark blue sky. The structure is partially illuminated, highlighting its intricate design.

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



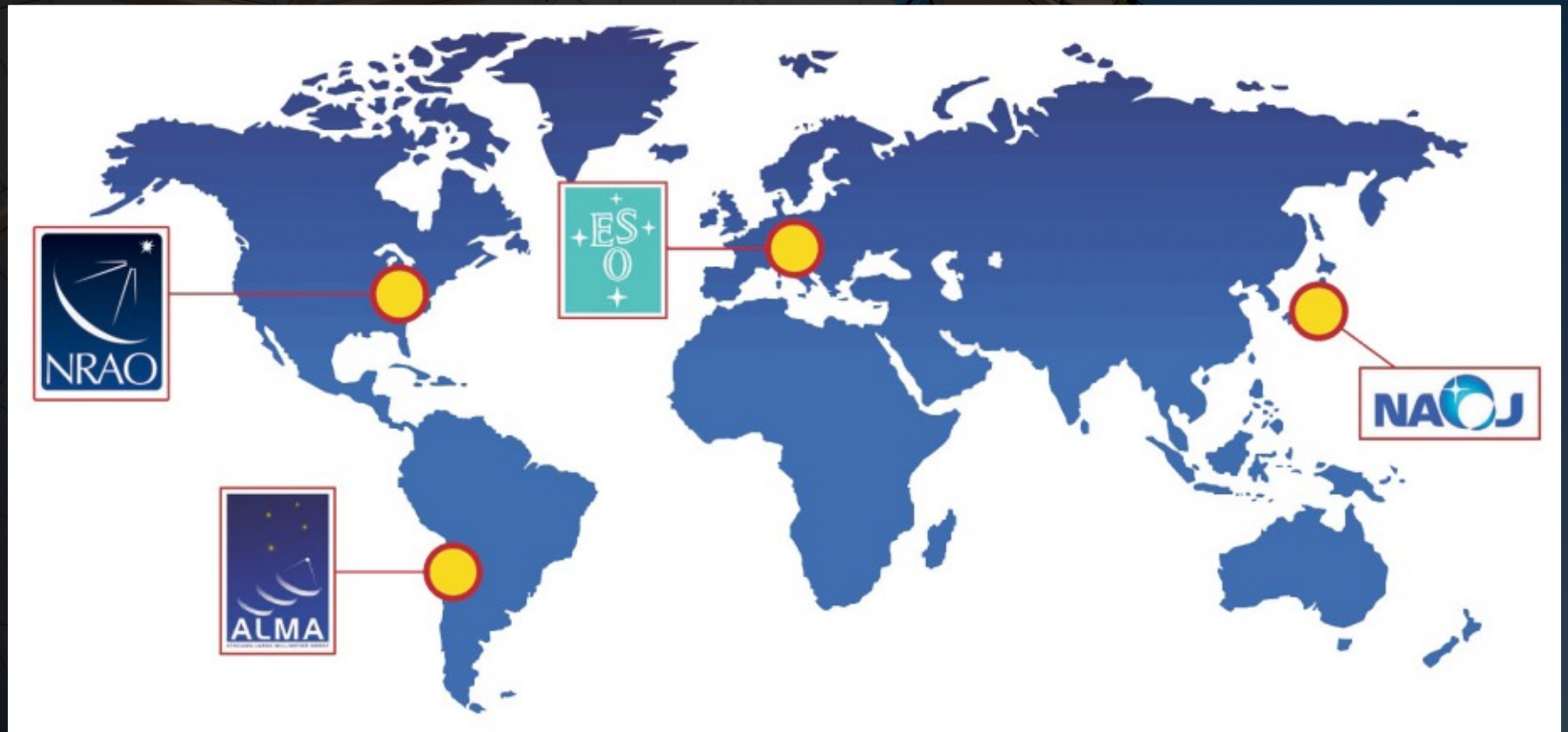
Additionally, ALMA now will accept Joint Proposals where observers can simultaneously apply for time on ALMA and the following observatories:

- 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).

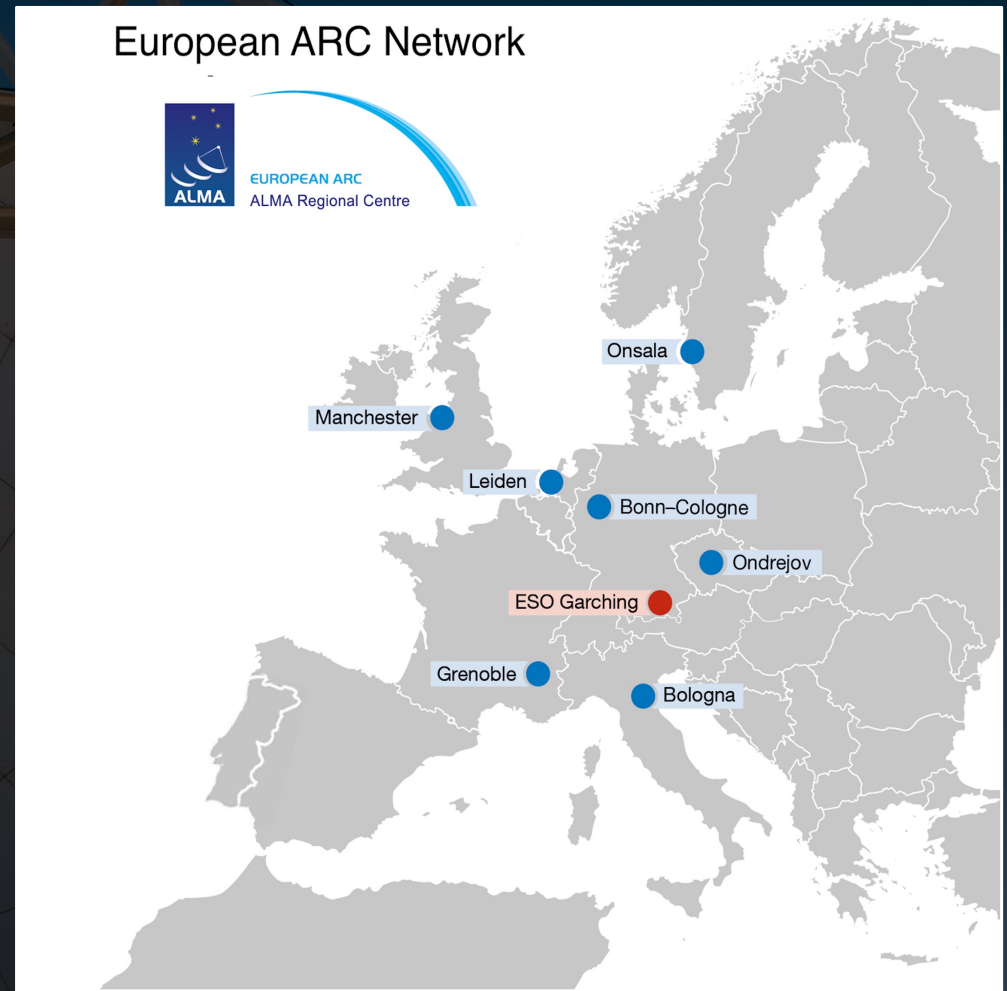
The Joint ALMA Office (JAO) in Chile coordinates all activities.



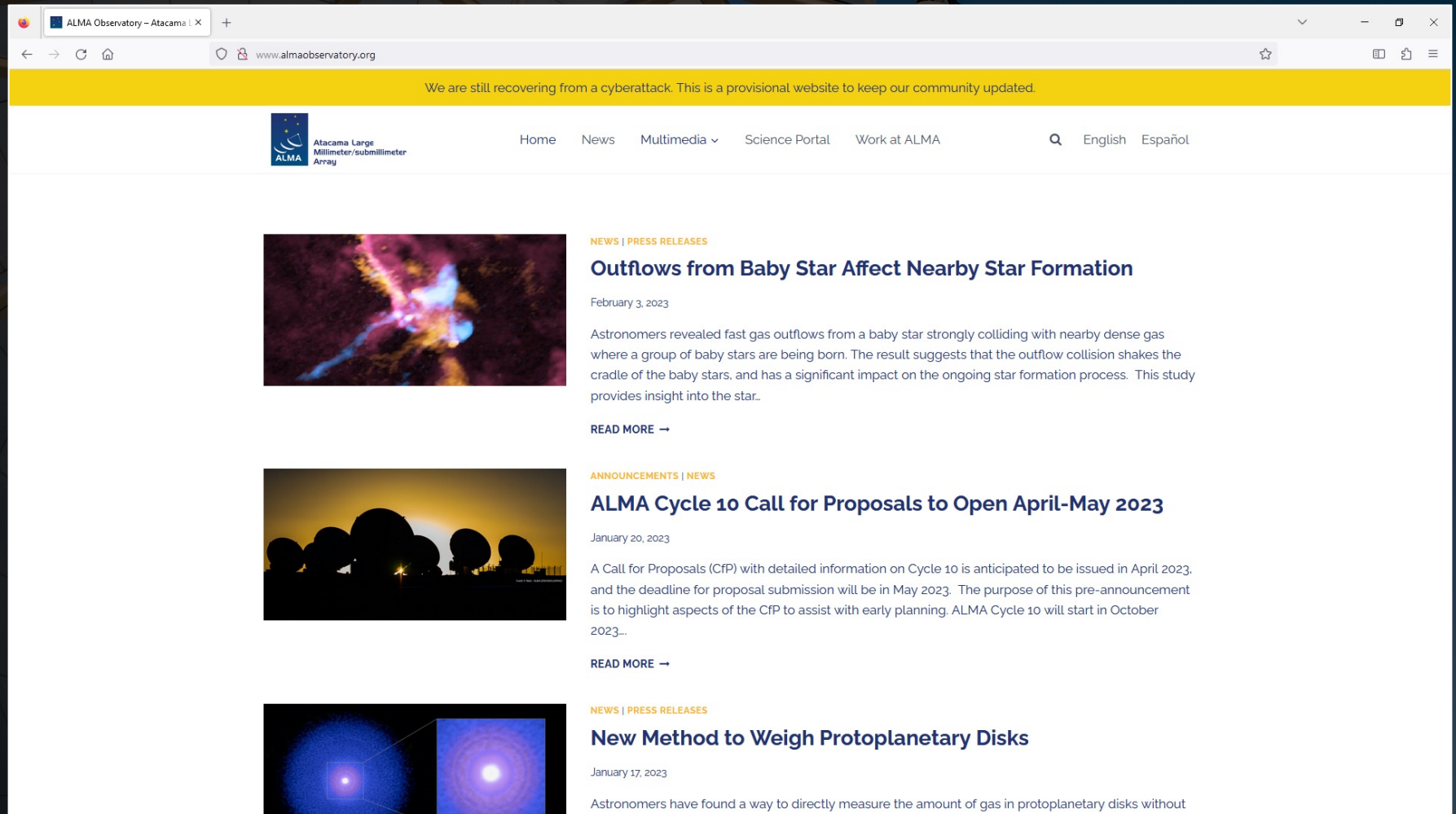
The European Southern Observatory coordinates ALMA activities in Europe.

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>.



The screenshot shows a web browser window with the URL [www.almaobservatory.org](http://www.almaobservatory.org). A yellow banner at the top of the page reads: "We are still recovering from a cyberattack. This is a provisional website to keep our community updated." The website header includes the ALMA logo (Atacama Large Millimeter/submillimeter Array) and navigation links for Home, News, Multimedia, Science Portal, and Work at ALMA. There are also language options for English and Español.

The main content area features three news articles:

- NEWS | PRESS RELEASES**  
**Outflows from Baby Star Affect Nearby Star Formation**  
February 3, 2023  
Astronomers revealed fast gas outflows from a baby star strongly colliding with nearby dense gas where a group of baby stars are being born. The result suggests that the outflow collision shakes the cradle of the baby stars, and has a significant impact on the ongoing star formation process. This study provides insight into the star.  
[READ MORE →](#)
- ANNOUNCEMENTS | NEWS**  
**ALMA Cycle 10 Call for Proposals to Open April-May 2023**  
January 20, 2023  
A Call for Proposals (CFP) with detailed information on Cycle 10 is anticipated to be issued in April 2023, and the deadline for proposal submission will be in May 2023. The purpose of this pre-announcement is to highlight aspects of the CFP to assist with early planning. ALMA Cycle 10 will start in October 2023...  
[READ MORE →](#)
- NEWS | PRESS RELEASES**  
**New Method to Weigh Protoplanetary Disks**  
January 17, 2023  
Astronomers have found a way to directly measure the amount of gas in protoplanetary disks without

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

The screenshot shows the ALMA Science Portal website. At the top, the navigation menu includes: About, Science, Proposing, Observing, Data, Processing, Tools, Documentation, and Help. The main content area is divided into several sections:

- Science Highlight:** Titled "Complex Organic Molecules in a Planet-Forming Disk", it features four panels of intensity maps for  $\text{CH}_3\text{OCH}_3$  ( $E_{\text{up}} = 72.9 \text{ K}$ ),  $\text{CH}_3\text{OH}$  ( $E_{\text{up}} = 332.0 \text{ K}$ ),  $\text{CH}_3\text{OCHO}$  ( $E_{\text{up}} = 303.9 \text{ K}$ ), and another  $\text{CH}_3\text{OCH}_3$  panel. Each panel shows a spatial distribution of the molecule in a planet-forming disk, with axes in RA and Dec degrees and a scale bar of 50 AU. A caption below reads: "Integrated intensity maps of the 0.9 mm continuum emission and emission from several COMs." A text block below the maps cites Brunken et al. (2022, A&A 659, A29) and describes the detection of complex organic molecules (COMs) in the disk of the young star IRS48.
- Observatory News:** Lists recent announcements such as "ALMA Cycle 10 Pre-Announcement" (Jan 18, 2023), "ALMA Cycle 9 Proposal Review: Detailed Report" (Jan 12, 2023), and "ALMA announces Joint Proposal agreements for JWST, VLA, and the VLT" (Dec 20, 2022).
- EU ARC News:** Includes "ALMA Regional Centre Astronomer - ESO Garching" (Nov 09, 2022), "Fifth European ALMA Regional Centre community assembly" (Mar 24, 2022), and "ALMA Regional Centre Astronomer - ESO Garching (closed)" (Dec 09, 2021).
- ALMA Status:** Shows "Configuration Schedule" with "Referred publications: 3148", "Last observed source: C29", and "Current configuration: C-4".

At the bottom, there is a "Quick Links" table and a footer with "Site Map", "Accessibility", "Contact", "Privacy Statement", and "Region: EA EU NA".

Quick Links	
<a href="#">ALMA Basics</a>	<a href="#">ALMA Archive</a>
<a href="#">ALMA Science</a>	<a href="#">SnooPI</a>
<a href="#">ALMA Primer</a>	<a href="#">Configuration Schedule</a>

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

The screenshot shows a web browser window with the URL <https://www.alma.ac.uk>. The page title is "UK ALMA Regional Centre".

**Local Information**

- Home
- About
- Directory
- Contact Information
- Visitor Information

**Science & Support Information**

- Meetings
- Newsletter
- PI Information
- Publications
- Public Outreach
- Software and Tools

**External Links**

- ALMA Regional Centres
- ALMA Observatory
- ESO
- NAOJ
- NRAO
- Documentation
  - Proposer's Guide
  - Technical Handbook
- Outreach
  - ESO ALMA Image Archive
  - ESO ALMA Video Archive
  - UK ARC Node Twitter

**UK ALMA Regional Centre**

EUROPEAN ARC  
ALMA Regional Centre || UK

Search ...

**The UK ARC Node**

Watch Later Share

Watch on YouTube

Video Credit: Ana A. Alpizar

**ALMA Cycle 10 Pre-Announcement**

ALMA has announced that the next Call for Proposals (CfP) will be in April 2023 with proposals due in May 2023. The current dates are as follows:

- 18 January 2023: Cycle 10 pre-announcement
- 12 April 2023: Release of the ALMA Cycle 10 CfP and Observing Tool, and opening of the archive for proposal submission
- 10 May 2023: Proposal submission deadline
- August 2023: Proposal review results sent to proposers
- 01 October 2023: Start of Cycle 10 observations

ALMA in Cycle 10 will have several new capabilities, including Band 1 observations, spectral scan observations that include Total Power, full polarization Band 3 solar observations, phased array modes in Bands 1, 3, 6, and 7, and VLBI in Bands 1, 3, 6, and 7. Additionally, Cycle 10 will introduce the option of submitting Joint Proposals with other observatories as discussed below.

More details are available from the [ALMA Cycle 10 Pre-Announcement](#).



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

The screenshot displays the ALMA Science Archive interface. At the top, there is a search bar and navigation icons. The main content area is split into two panels. The left panel shows a spectral plot with a diamond-shaped mosaic pattern overlaid on a dark background. The right panel shows a spectral plot with several labeled lines and their corresponding molecules and redshifts. Below the plots, there is a table of observations with columns for Project code, ALMA source name, RA, Dec, Band, Cont. sens., Frequency support, Release date, Publications, Ang. res., Min. vel. res., Array, Mosaic, Max. reco. scale, FOV, and Scienti.

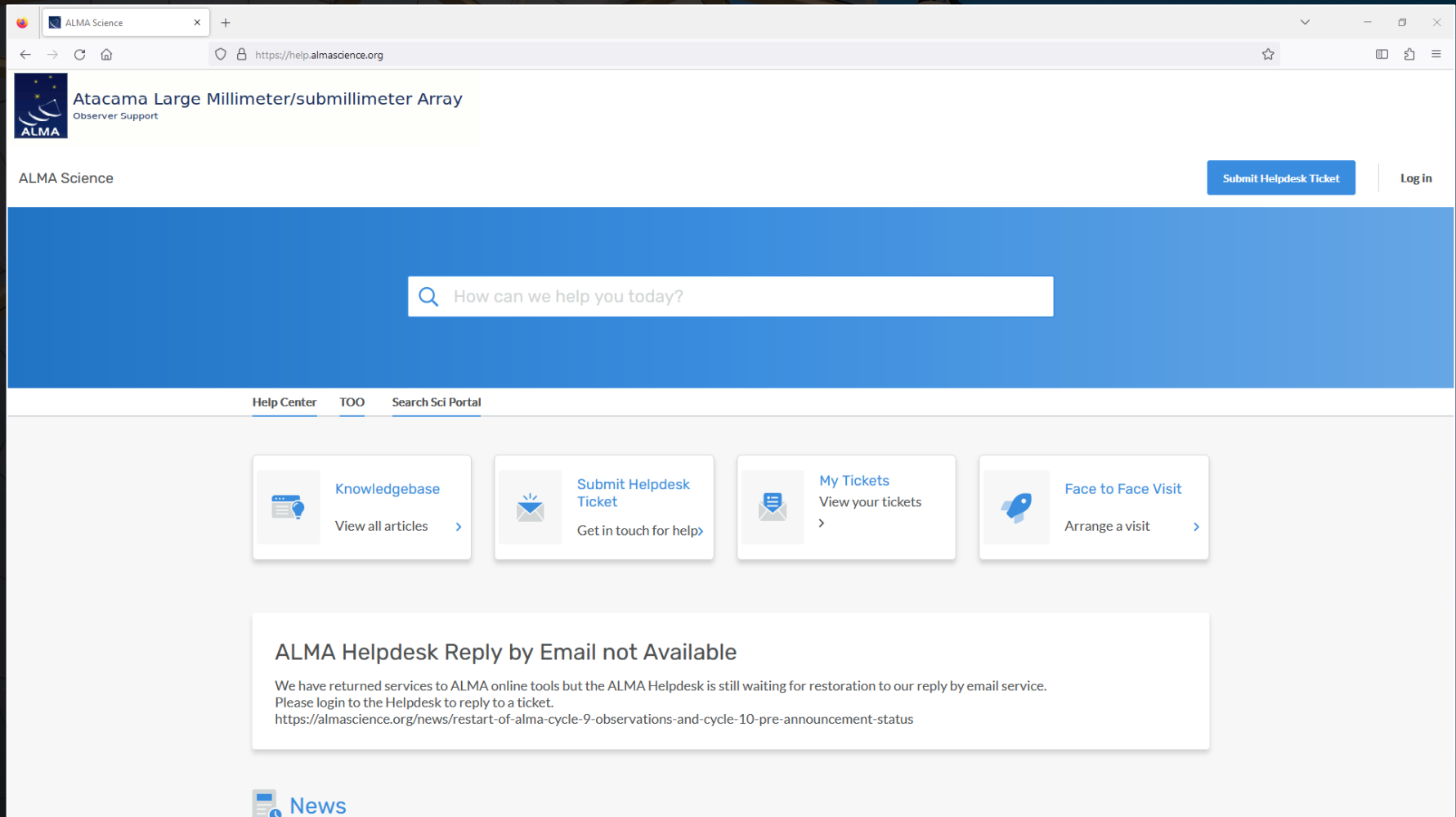
**Molecules and Lines:**

- 3: CO v=0-0, J=1-0
- 4: CS v=0-0, J=2-1
- 5: H<sub>2</sub>CO v=0-0, J=2-1
- 6: CO v=0-0, J=3-2
- 7: CH<sub>3</sub>OH v=0-0, J=3-2
- 8: HNC v=0-0, J=4-3
- 9: H<sub>2</sub>O v=0-0, J=2-1
- 10: H<sub>2</sub>O v=0-0, J=3-2

**Observations Table:**

Project code	ALMA source name	RA	Dec	Band	Cont. sens.	Frequency support	Release date	Publications	Ang. res.	Min. vel. res.	Array	Mosaic	Max. reco. scale	FOV	Scienti
		hms	dms		mJy/beam				arcsec	km/s			arcsec	arcsec	
2011.0.00181.S	Fomalhaut b	22:57:38.685	-29:37:12.616	7	0.1181	343.077-358.839 GHz	2012-12-06	2	1.047	0.816	12m		10.640	16.592	Disks a
2011.0.00181.S	R Scl	01:26:58.079	-32:32:36.424	7	0.9115	330.246-346.109 GHz	2012-12-06	5	1.043	0.846	12m	mosaic	11.517	62.007	Stars at
2011.0.00101.S	GRB021004	00:26:54.680	+18:55:41.600	7	0.1136	337.009-353.001 GHz	2012-12-06	2	1.107	26.541	12m		9.258	16.878	Active
2011.0.00397.S	J035448.24-330827.2	03:54:48.240	-33:08:27.200	7	0.4848	337.026-353.011 GHz	2012-12-20	3	1.128	26.541	12m		7.950	16.877	Active
2011.0.00397.S	J041754.10-281655.9	04:17:54.100	-28:16:55.900	7	0.4848	337.023-353.008 GHz	2012-12-20	3	1.118	26.541	12m		7.842	16.877	Active
2011.0.00397.S	J061200.23-062209.6	06:12:00.230	-06:22:09.600	7	0.5346	337.005-352.989 GHz	2012-12-20	3	1.183	26.541	12m		7.819	16.878	Active
2011.0.00397.S	J063027.81-212058.6	06:30:27.810	-21:20:58.600	7	0.5346	337.007-352.992 GHz	2012-12-20	3	1.183	26.541	12m		8.015	16.878	Active
2011.0.00397.S	J054930.06-373940.1	05:49:30.060	-37:39:40.100	7	0.4848	337.016-353.001 GHz	2012-12-20	3	1.156	26.541	12m		7.888	16.878	Active
2011.0.00397.S	J070257.20-280842.3	07:02:57.200	-28:08:42.300	7	0.5346	337.006-352.991 GHz	2012-12-20	3	1.154	26.541	12m		8.053	16.878	Active
2011.0.00397.S	J030427.53-310838.3	03:04:27.530	-31:08:38.300	7	0.4848	337.029-353.015 GHz	2012-12-20	3	1.142	26.541	12m		8.026	16.877	Active

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 screenshot shows a web browser window with the URL <https://help.almascience.org>. The page header includes the ALMA logo and the text "Atacama Large Millimeter/submillimeter Array Observer Support". Below the header, there is a search bar with the placeholder text "How can we help you today?". The main content area features four service tiles: "Knowledgebase" (View all articles), "Submit Helpdesk Ticket" (Get in touch for help), "My Tickets" (View your tickets), and "Face to Face Visit" (Arrange a visit). A prominent message states "ALMA Helpdesk Reply by Email not Available" and provides a link to a news article about the restart of the ALMA cycle. The footer includes a "News" link.

ALMA Science [Submit Helpdesk Ticket](#) [Log in](#)


How can we help you today?

[Help Center](#) [TOO](#) [Search Sci Portal](#)

-  **Knowledgebase**  
View all articles >
-  **Submit Helpdesk Ticket**  
Get in touch for help>
-  **My Tickets**  
View your tickets >
-  **Face to Face Visit**  
Arrange a visit >

**ALMA Helpdesk Reply by Email not Available**

We have returned services to ALMA online tools but the ALMA Helpdesk is still waiting for restoration to our reply by email service. Please login to the Helpdesk to reply to a ticket.  
<https://almascience.org/news/restart-of-almata-cycle-9-observations-and-cycle-10-pre-announcement-status>

 [News](#)

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

## Observing with ALMA – A Primer (Cycle 9)

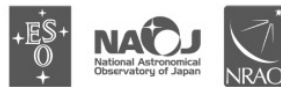


[www.almascience.org](http://www.almascience.org)

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## ALMA Cycle 9 Proposer’s Guide



[www.almascience.org](http://www.almascience.org)

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

Doc 9.3, ver. 1.0 | March 14<sup>th</sup>, 2022

## ALMA Cycle 9 Technical Handbook



[www.almascience.org](http://www.almascience.org)

ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), MOST and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ.

## Using ALMA archival data - A Primer

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



[www.almascience.org](http://www.almascience.org)

## Cycle 9 cyberattack

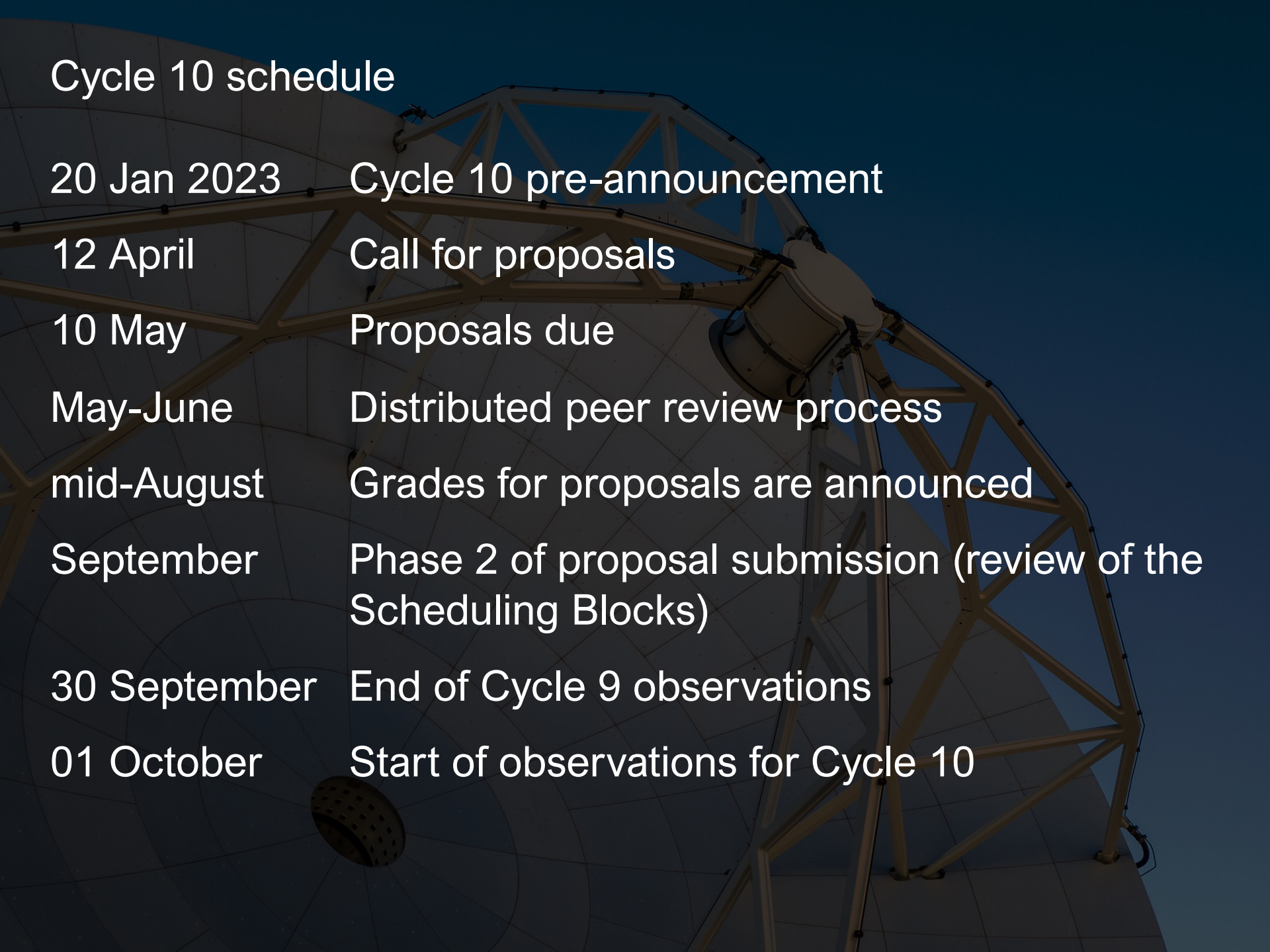
On 29 October 2022, ALMA suffered a cyberattack. This did not affect any astronomical data, but observing and several other activities halted as a precaution.

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:

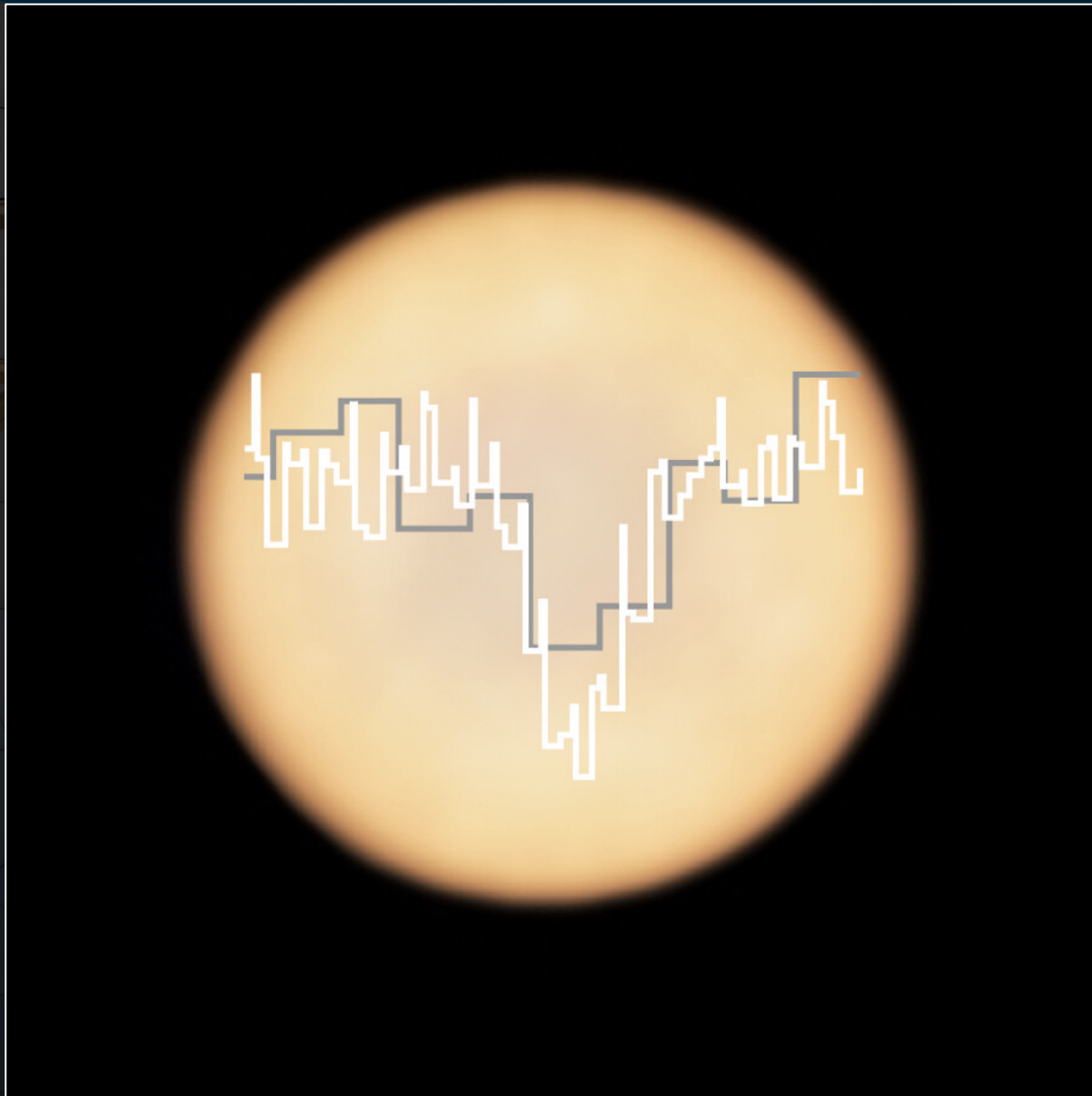
- Most observations with the most compact 12m configurations were not performed.
- The proposal schedule for Cycle 10 was pushed back.

## Cycle 10 schedule

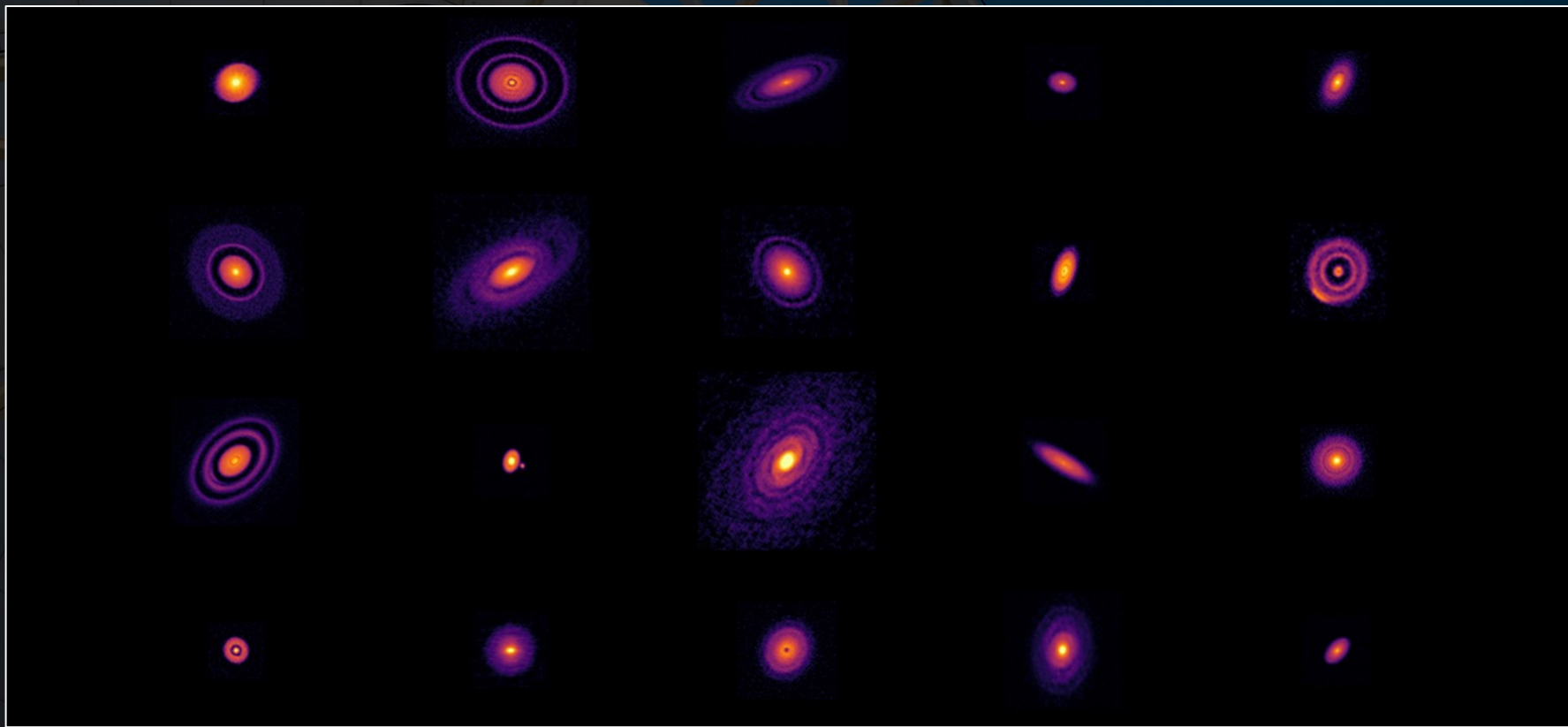


20 Jan 2023	Cycle 10 pre-announcement
12 April	Call for proposals
10 May	Proposals due
May-June	Distributed peer review process
mid-August	Grades for proposals are announced
September	Phase 2 of proposal submission (review of the Scheduling Blocks)
30 September	End of Cycle 9 observations
01 October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



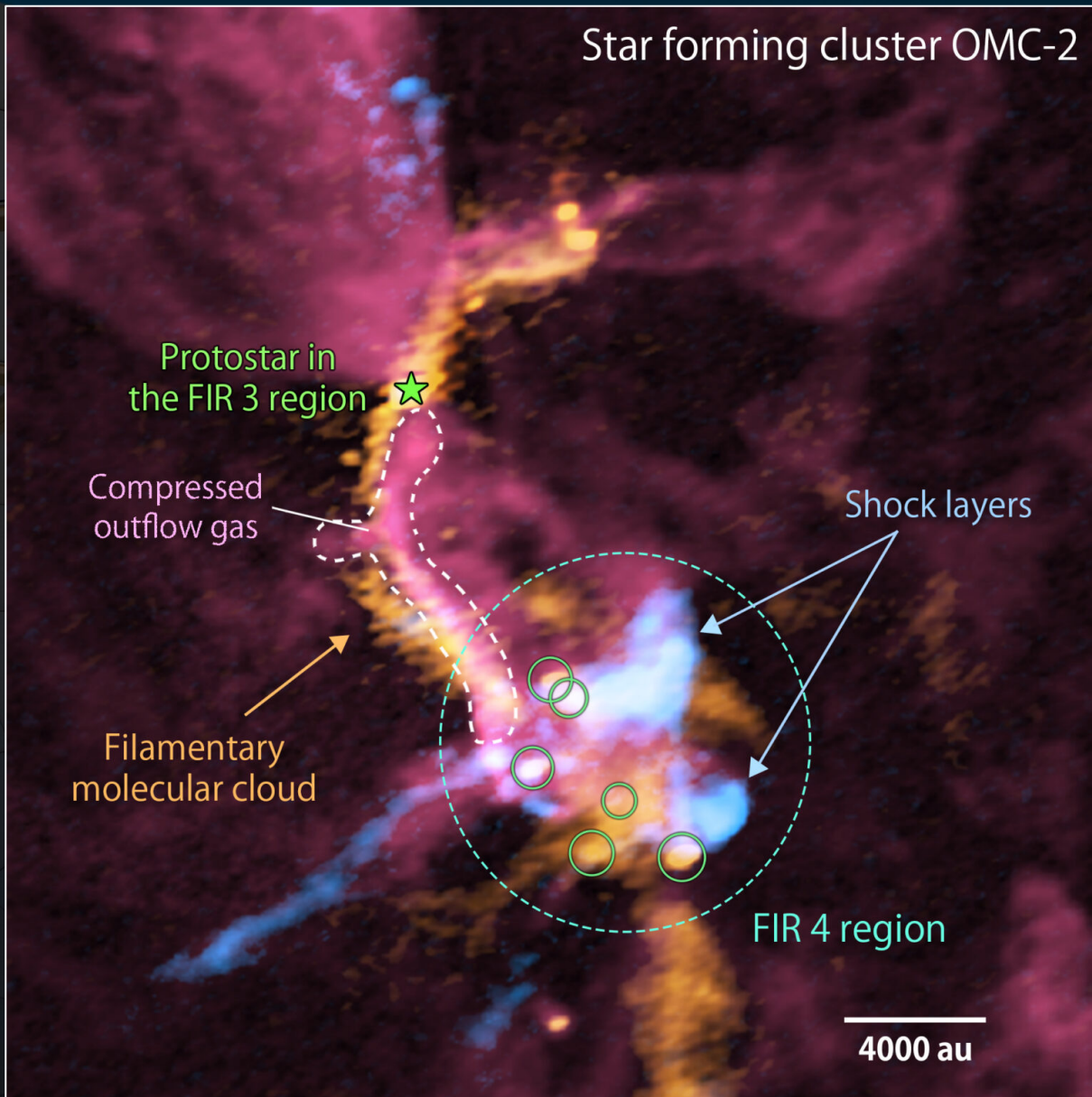


(Credit: ALMA (ESO/NAOJ/NRAO), Greaves et al. & JCMT (East Asian Observatory))

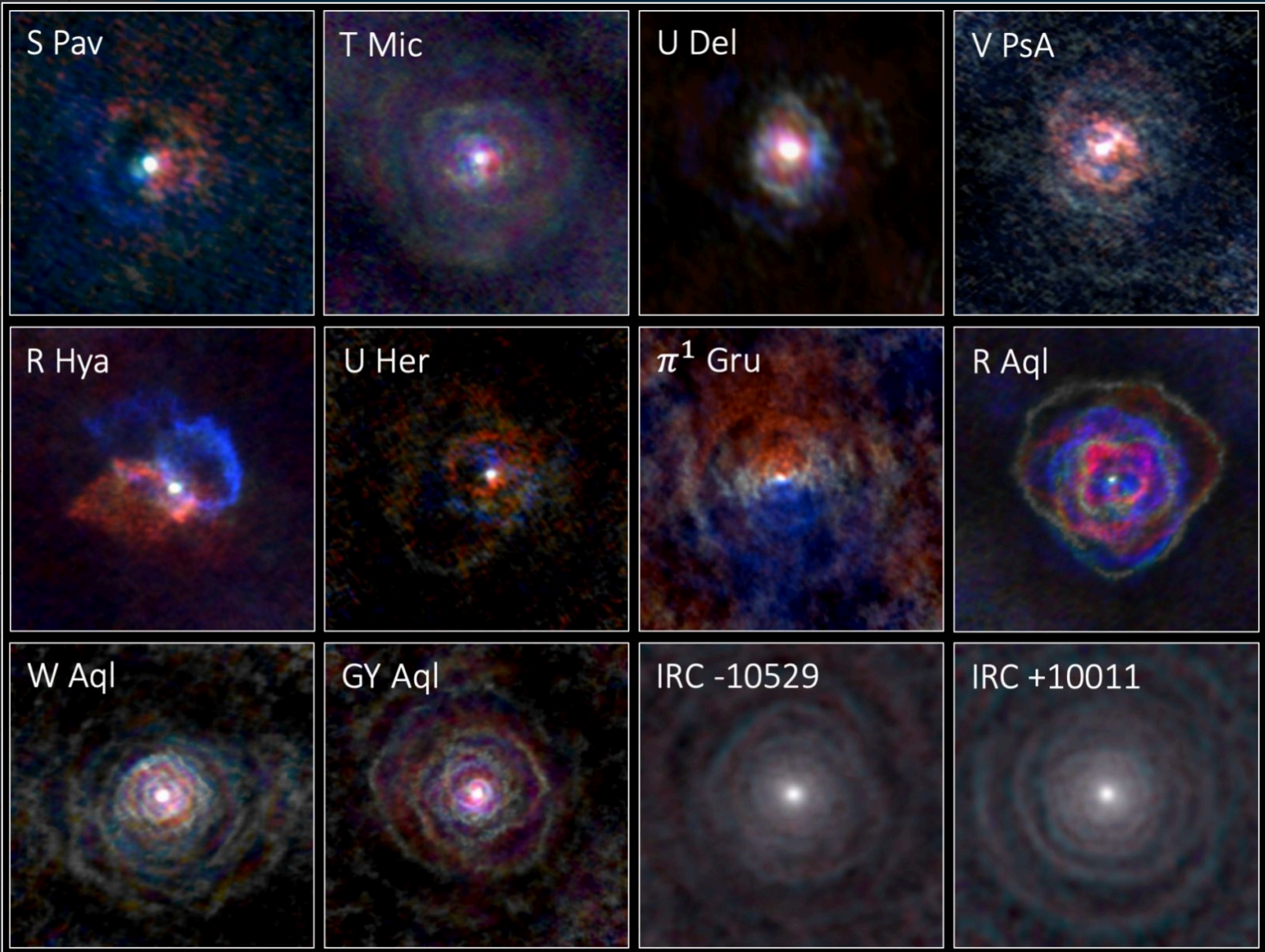


(Credit: ALMA (ESO/NAOJ/NRAO), S. Andrews et al.; N. Lira)

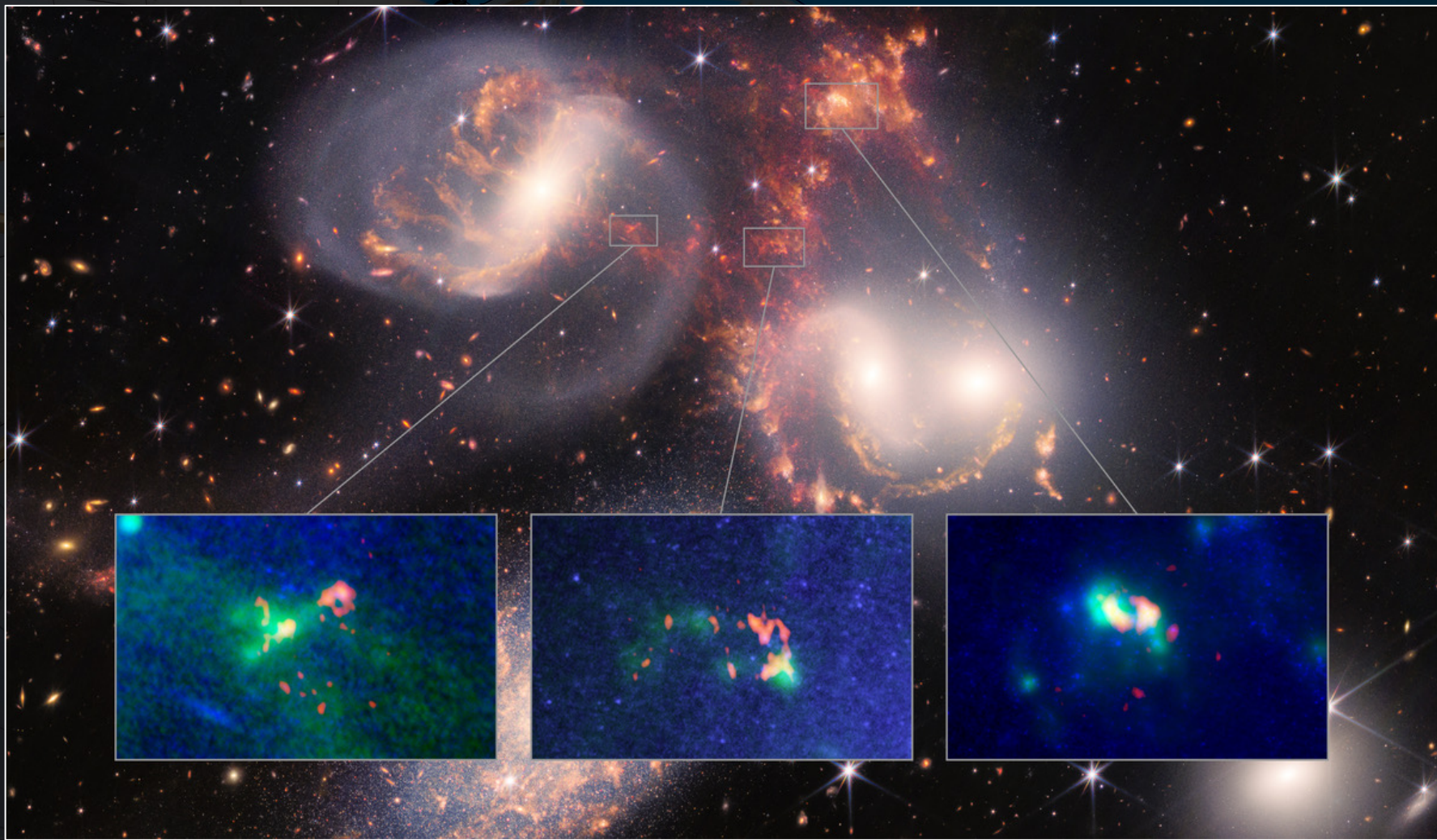
# Star forming cluster OMC-2



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



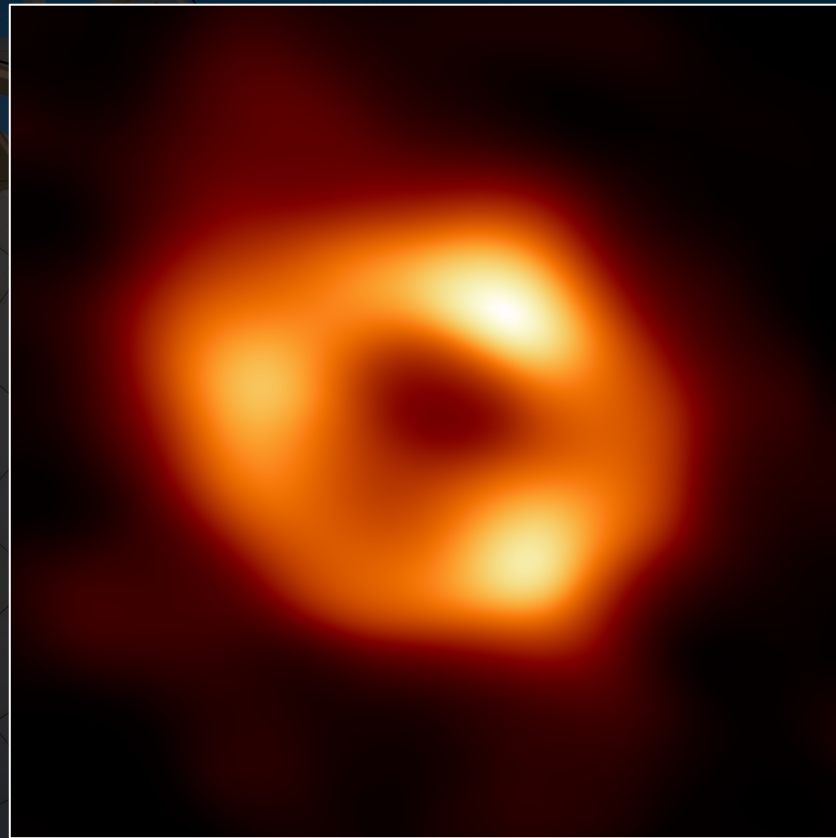
(Credit: L. Decin – ESO – ALMA)



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



(Credit: EHT Collaboration)

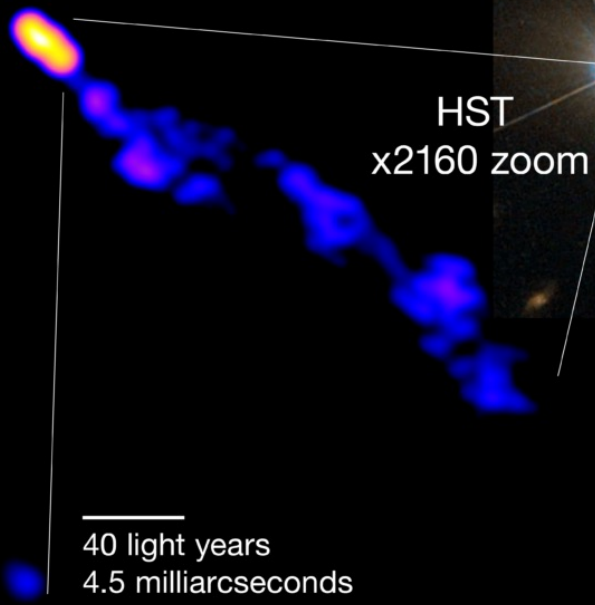
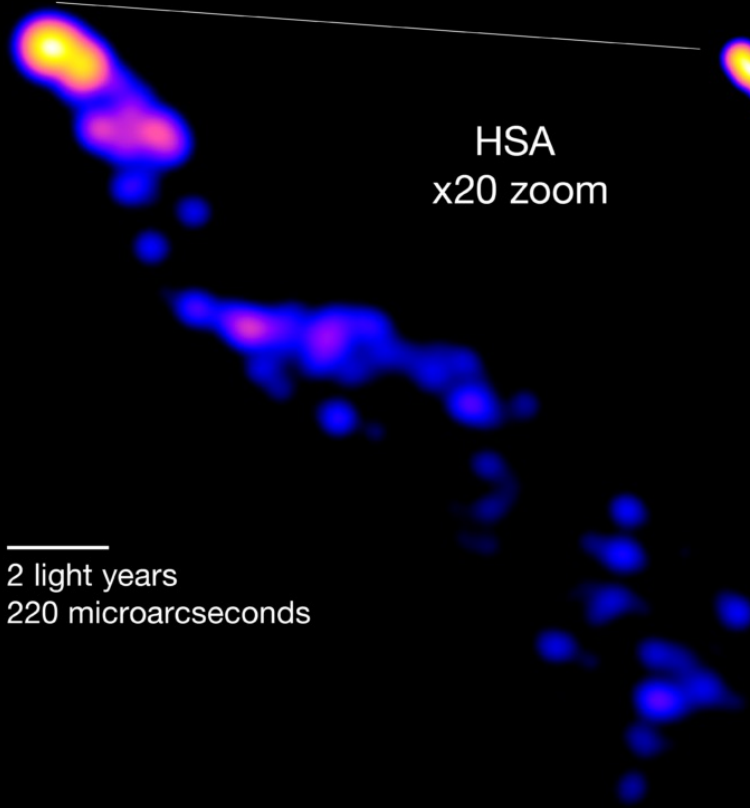


(Credit: EHT Collaboration)

GMVA+ALMA 3 mm

HSA 2 cm

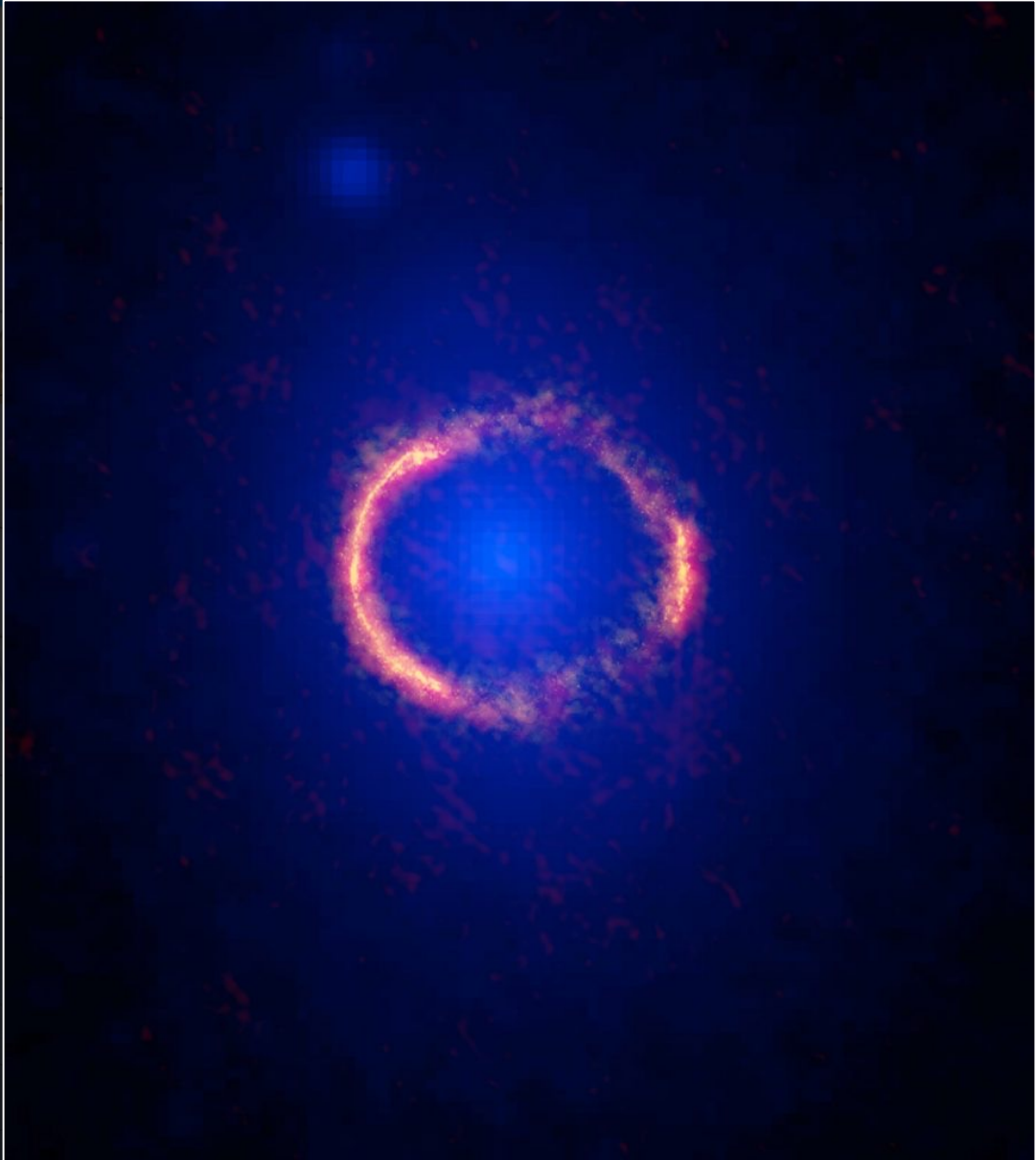
HST Optical



86,000 light years  
9.7 arcseconds

# The first quasar 3C 273

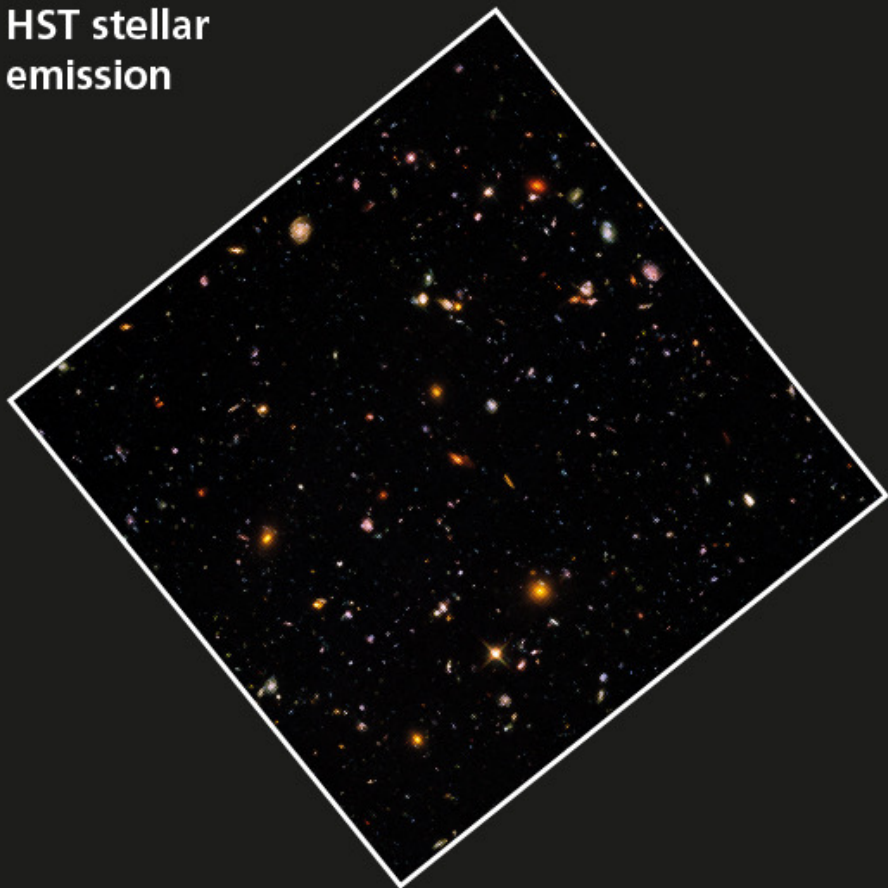
(Credits: Hiroki Okino and Kazunori Akiyama; GMVA+ALMA and HSA images: Okino et al.; HST Image: ESA/Hubble & NASA)



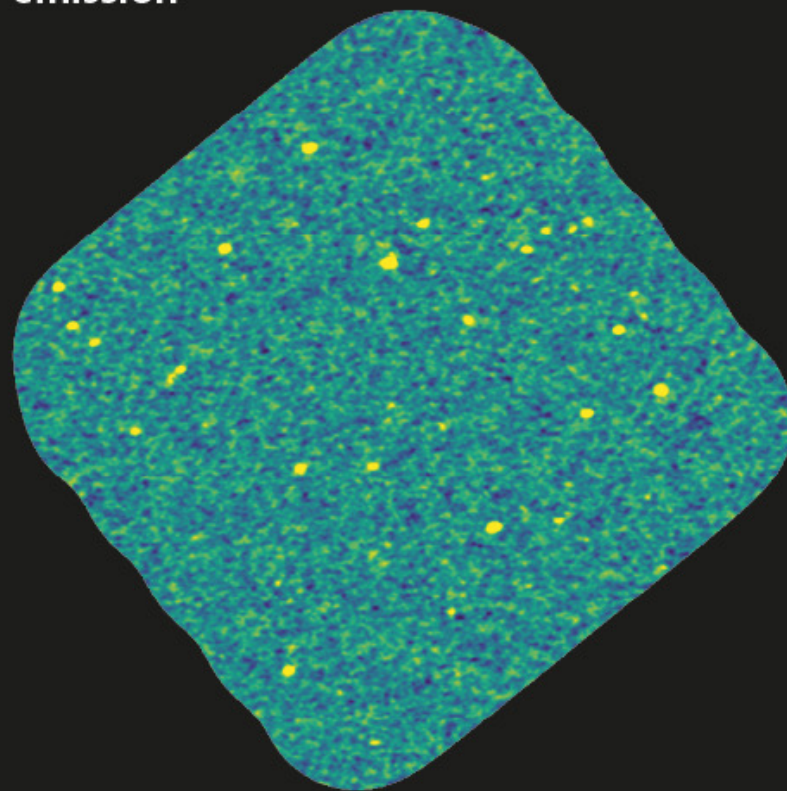
(Credit: ALMA (NRAO/ESO/NAOJ); B. Saxton NRAO/AUI/NSF; NASA/ESA Hubble, T. Hunter (NRAO))



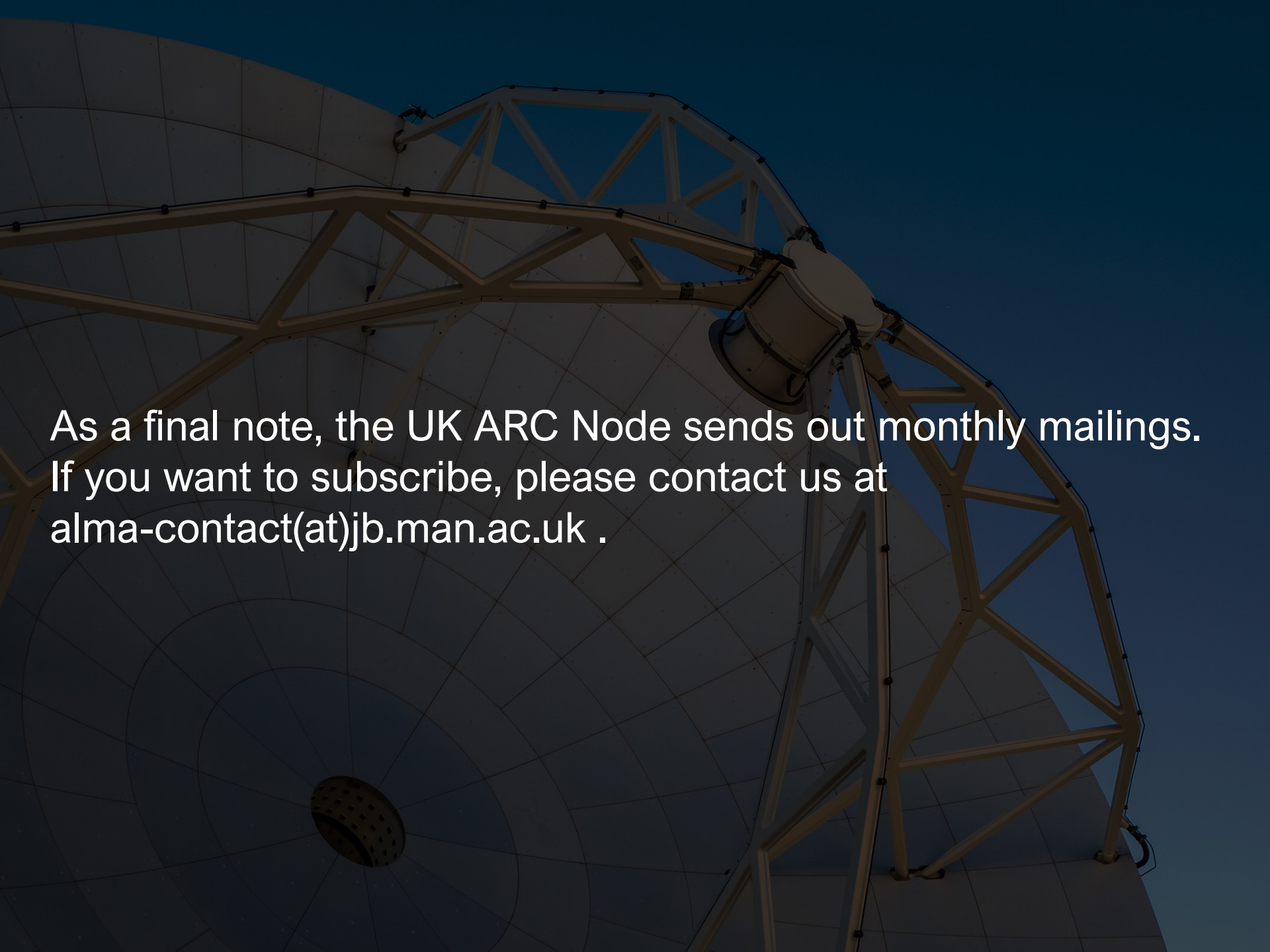
HST stellar  
emission



ALMA dust  
emission



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

A large radio telescope dish is shown from a low angle, looking up. The dish is a large, curved, metallic structure with a grid of panels. It is supported by a complex, multi-level metal truss structure. The sky is a deep, dark blue. The text is overlaid on the left side of the image.

As a final note, the UK ARC Node sends out monthly mailings.  
If you want to subscribe, please contact us at  
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