

# ***An Introduction to ALMA***

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UK ALMA Regional Centre Node  
Jodrell Bank Centre for Astrophysics  
The University of Manchester











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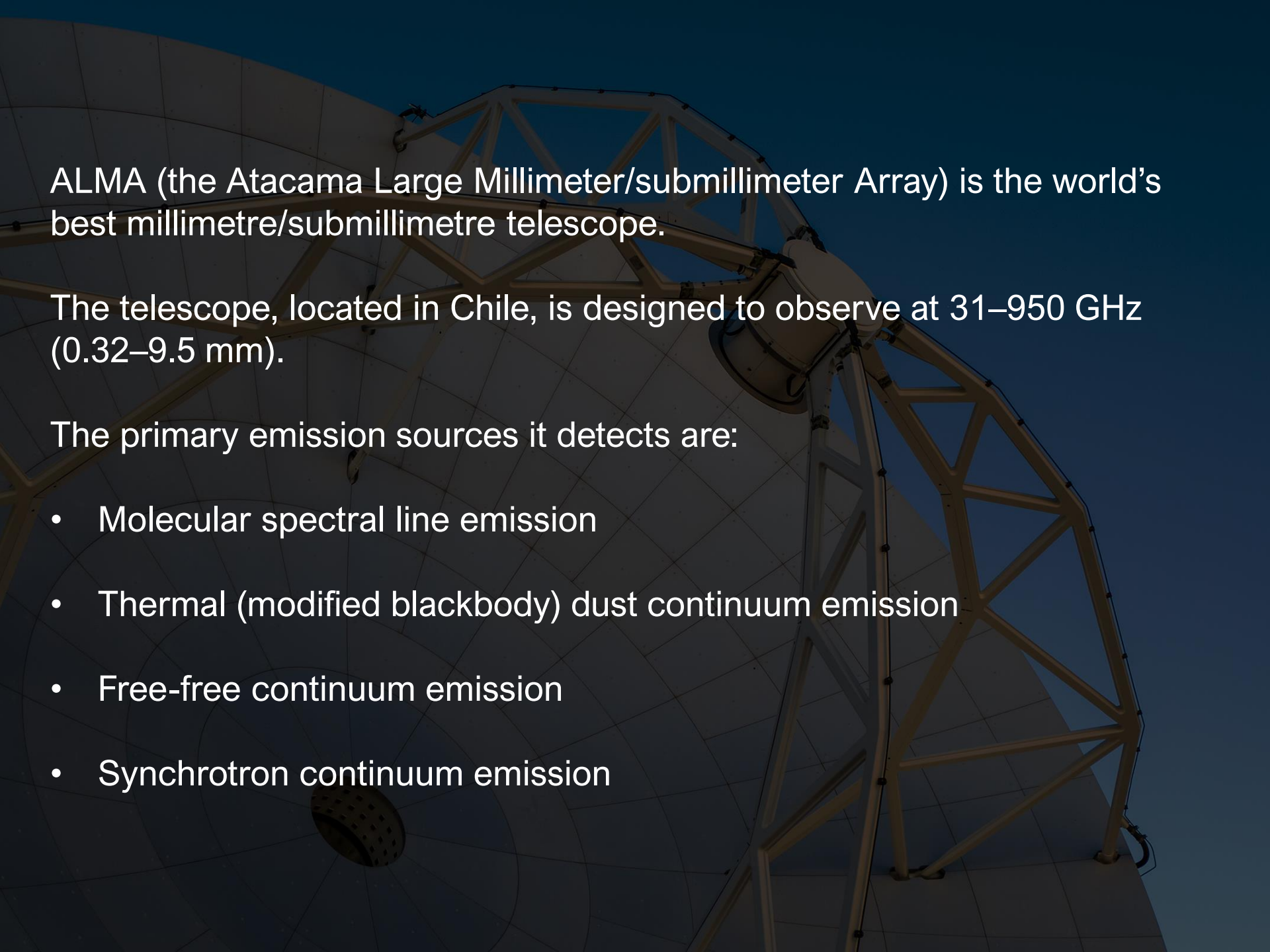












ALMA (the Atacama Large Millimeter/submillimeter Array) is the world's best millimetre/submillimetre telescope.

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:

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



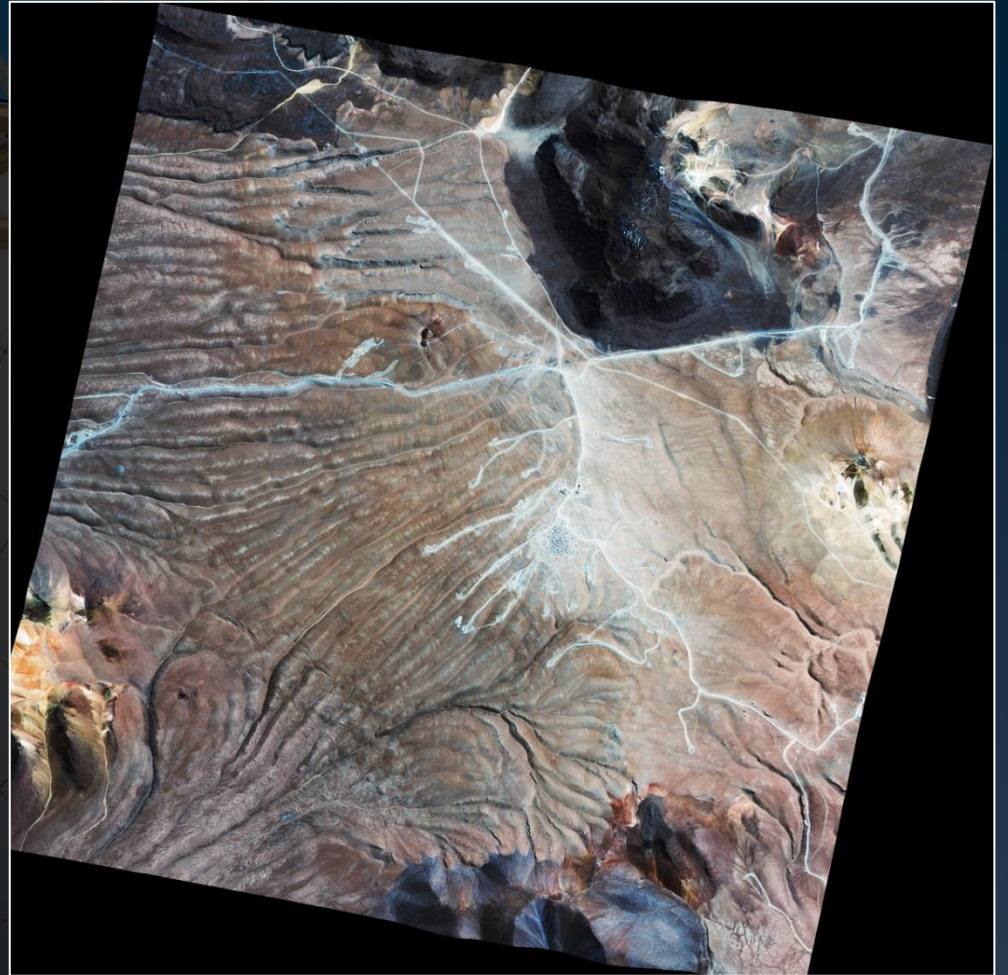
Some of the science performed with ALMA includes:

- 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.

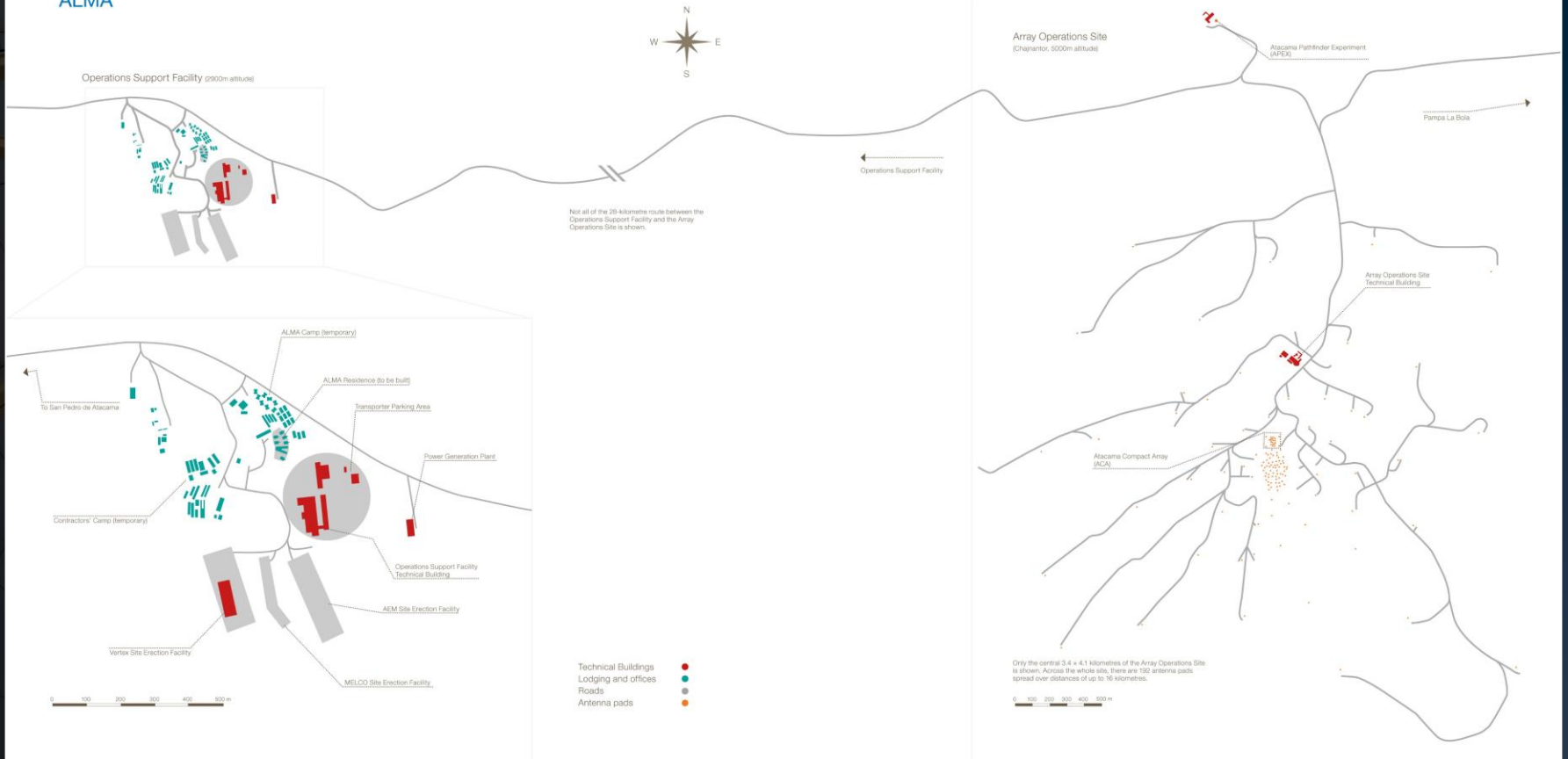
Because the air is cold and dry, the site is ideal for observing in submillimetre and millimetre bands.



(Credit: Aerophotogrammetry Service, Chilean Air Force)



# ALMA



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



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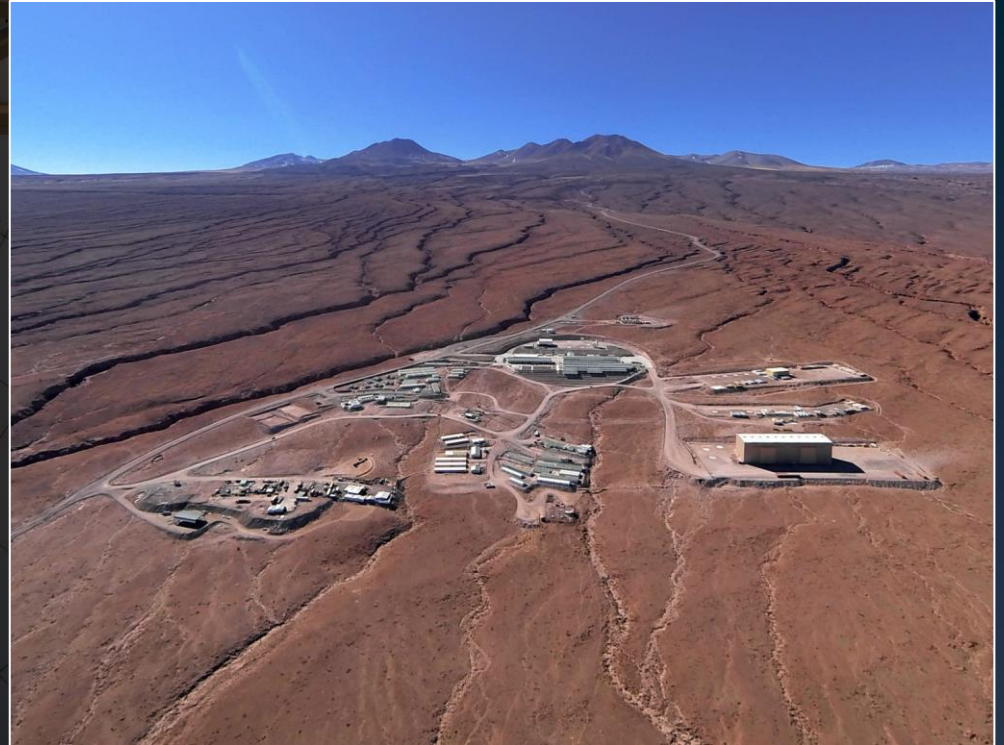


(Credit: ESO/S. Fandango)



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: ESO)



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



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

ALMA uses multiple sets of heterodyne receivers.

9 bands are available in Cycle 11.

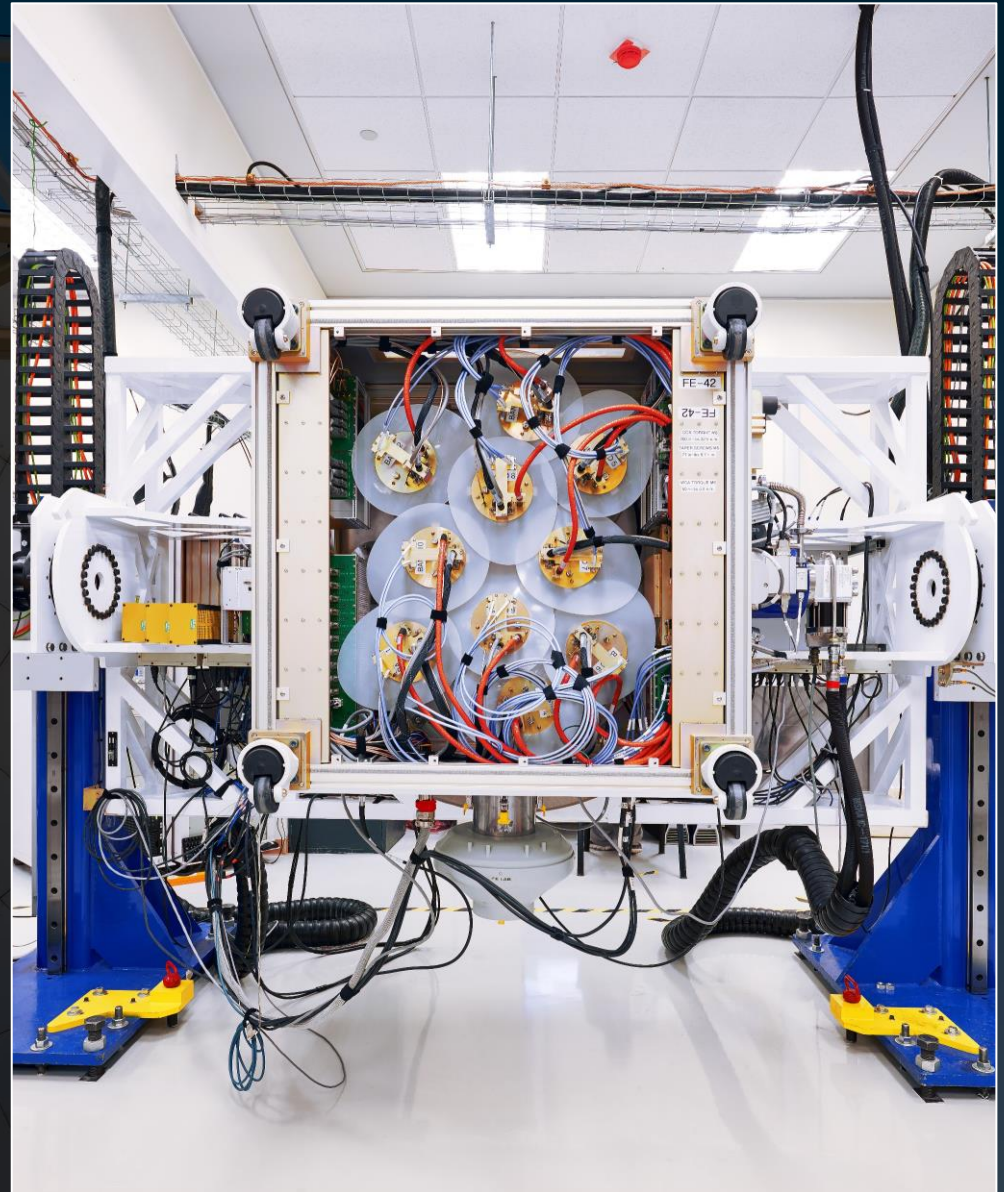


(Credit: ASIAA/NAOJ/ESO/S. Guisard ([www.eso.org/~sguisard](http://www.eso.org/~sguisard)))



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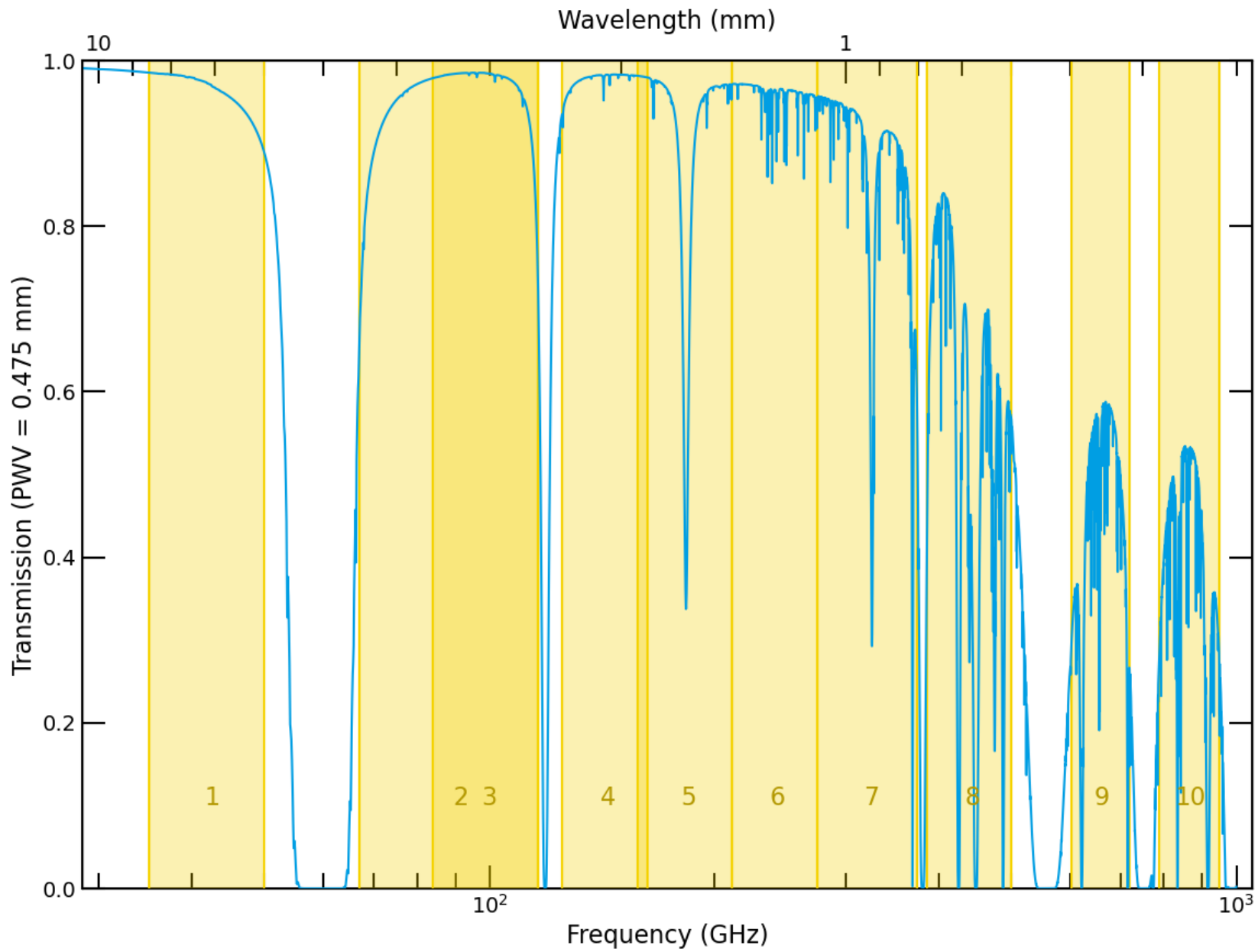
9 bands are available in Cycle 10.



(Credit: Enrico Sacchetti/ESO)

Band	Frequency (GHz)	Wavelength (mm)	Primary Beam (arcsec)	Angular Resolution (arcsec)	
				Compact Configuration	Extended Configuration
1	35-50	6-8.5	142	8.6	0.230
2	67-116	2.6-4.5	72	4.0	0.111
3	84-116	2.6-3.6	63	3.5	0.097
4	125-163	1.8-2.4	43	2.4	0.067
5	163-211	1.4-1.9	30	1.9	0.053
6	211-275	1.1-1.4	25	1.4	0.039
7	275-373	0.80-1.09	19	1.1	0.029
8	385-500	0.60-0.78	14	0.78	0.021
9	602-720	0.42-0.50	9.2	0.52	0.014
10	787-950	0.32-0.38	7.1	0.40	0.011





ALMA has three subarrays that observe different-sized structures:

- The 12m Array (50 antennas with 12m diameters)
- The 7m Array (12 antennas with 7m diameters)
- The Total Power antennas (4 antennas with 12m diameters)



(Credit: ESO)



The 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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(Credit: ESO)



The 7m Array 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.



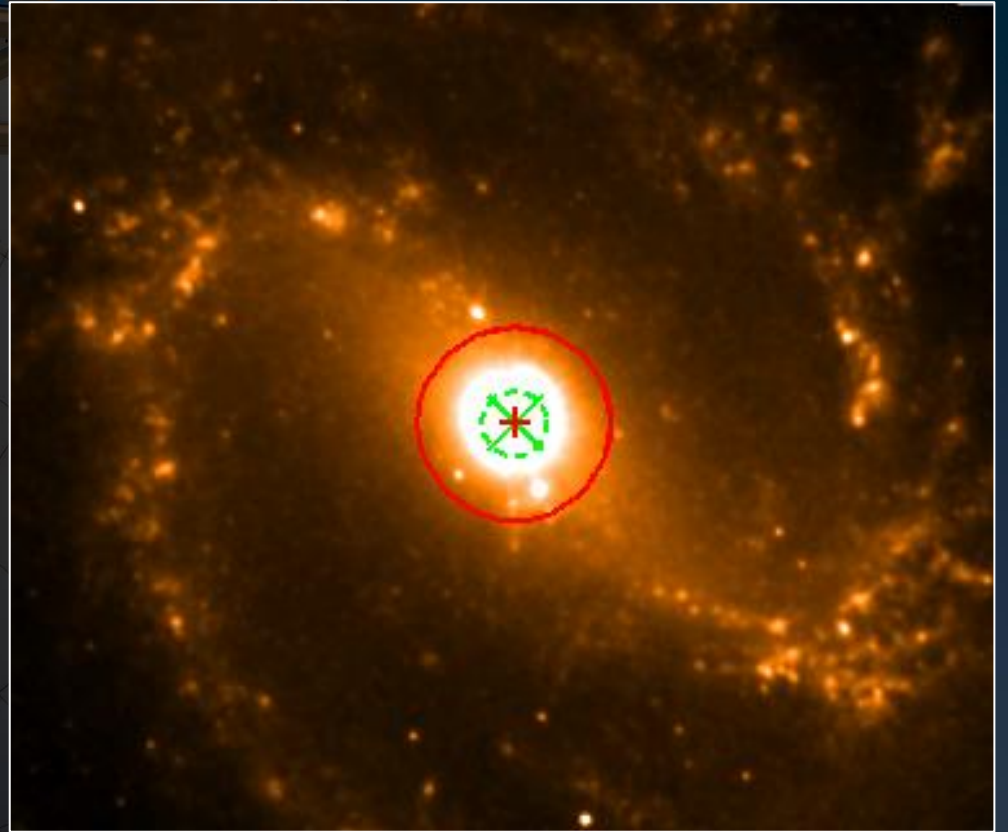
The Total Power antennas are used to detect large-scale line emission resolved out by both the 12m and 7m Arrays.





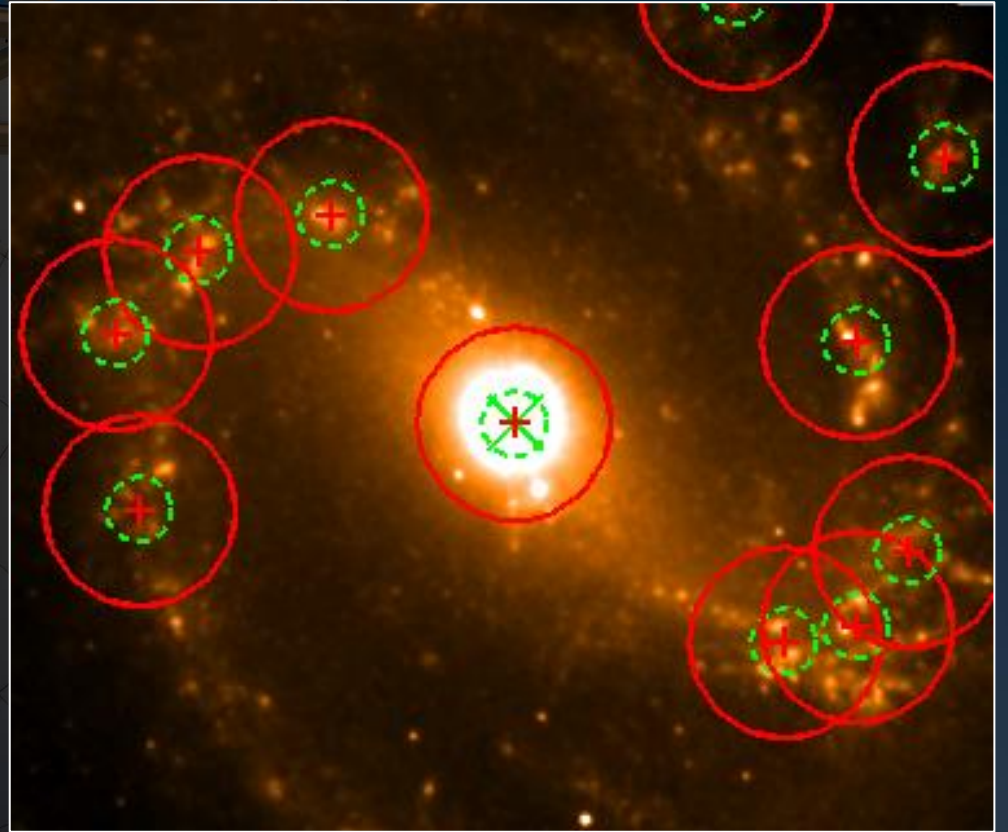
The most basic field that can be imaged by ALMA is a single pointing.

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



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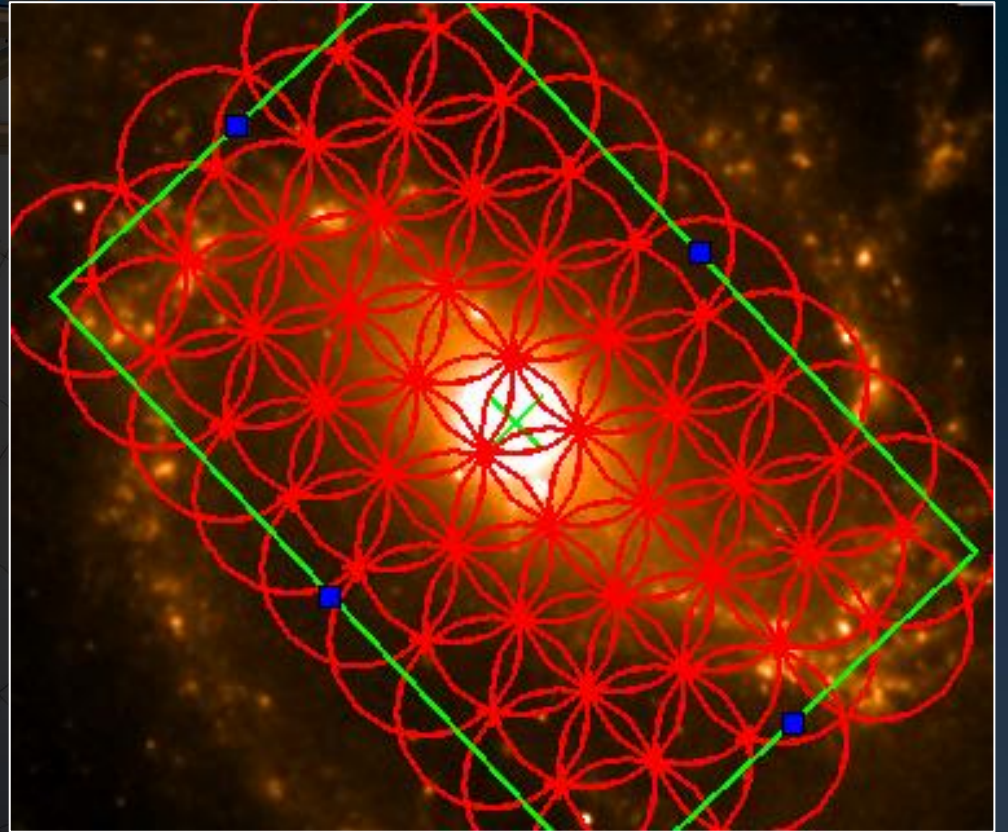
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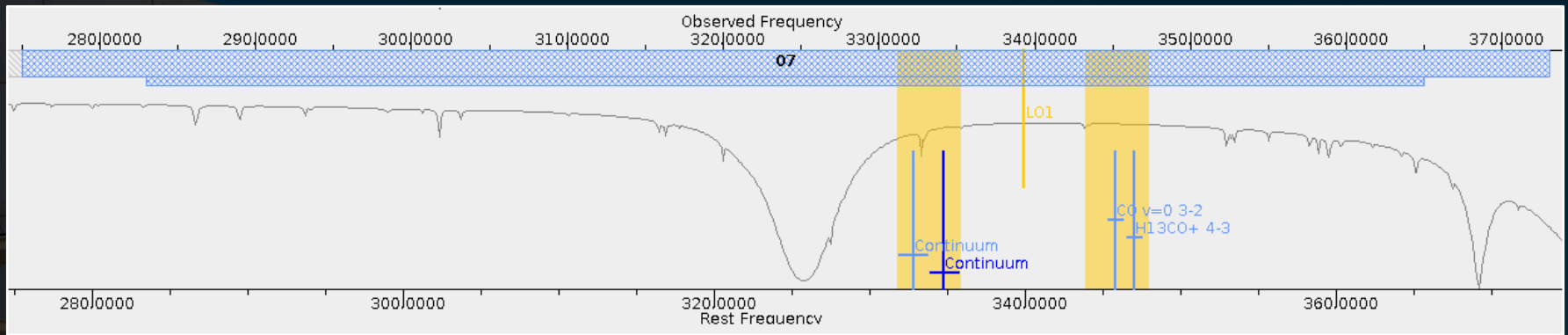




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However, ALMA can also image multiple pointings as a set of observations of one target or mosaic a rectangular field.





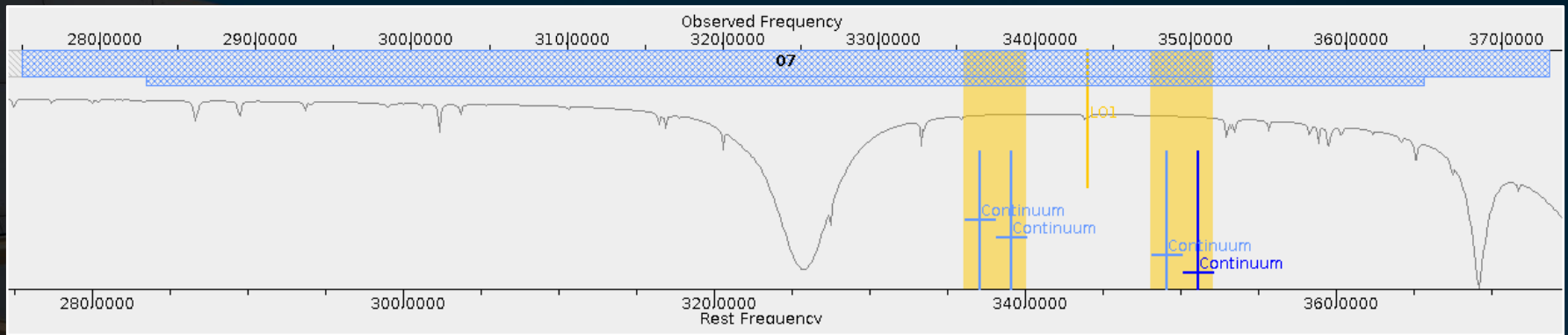
ALMA currently offers three types of spectral set-ups.

- 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 7m Array).



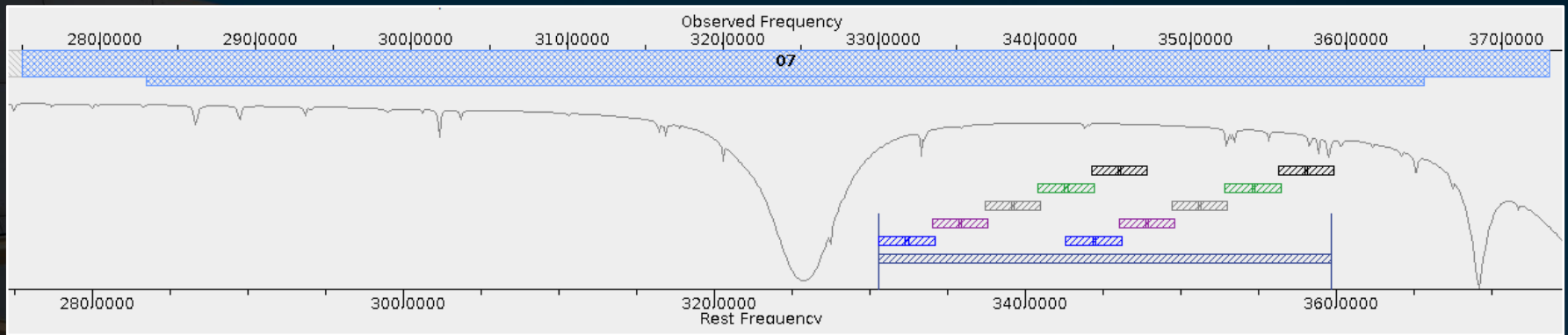


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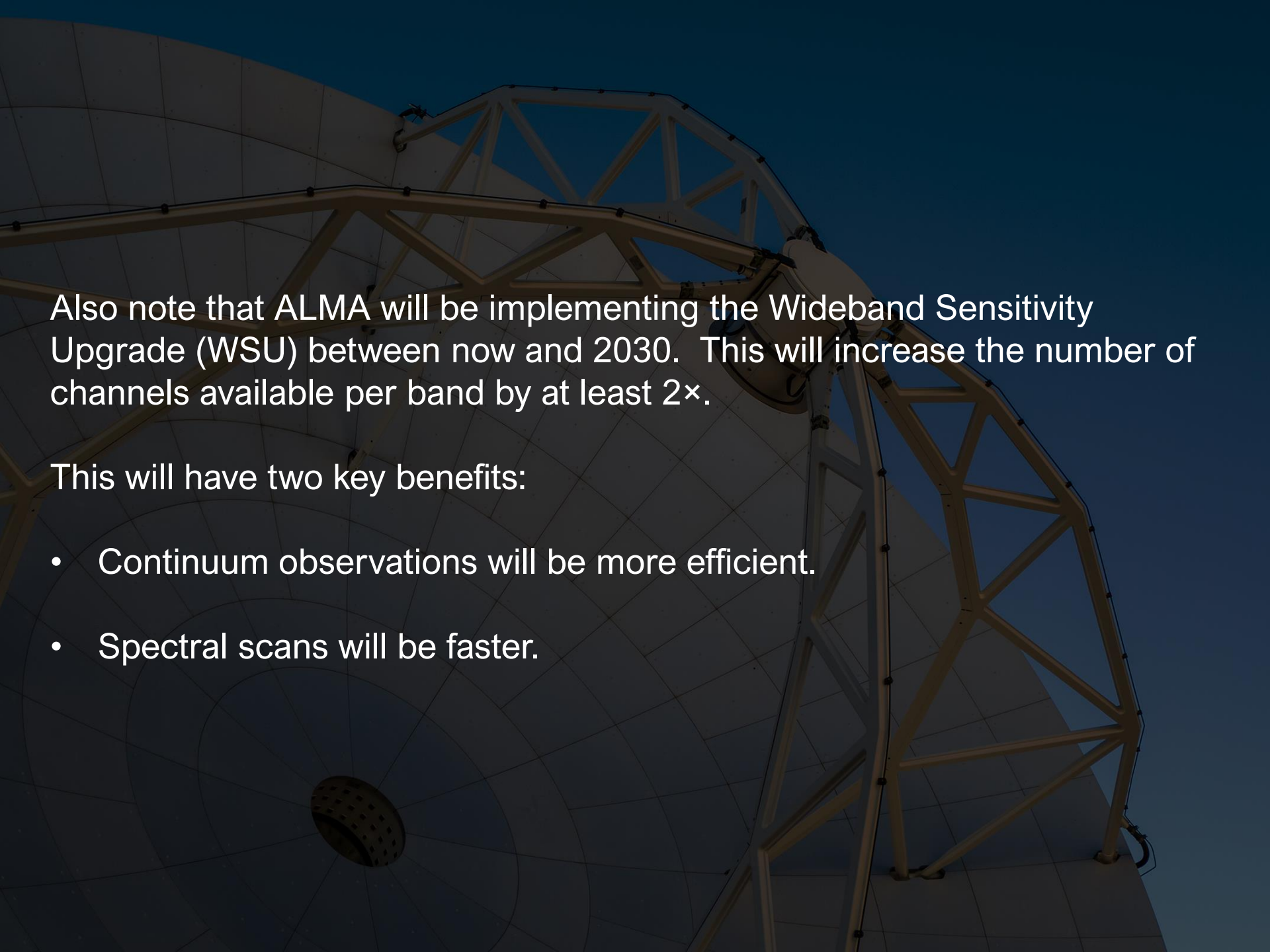
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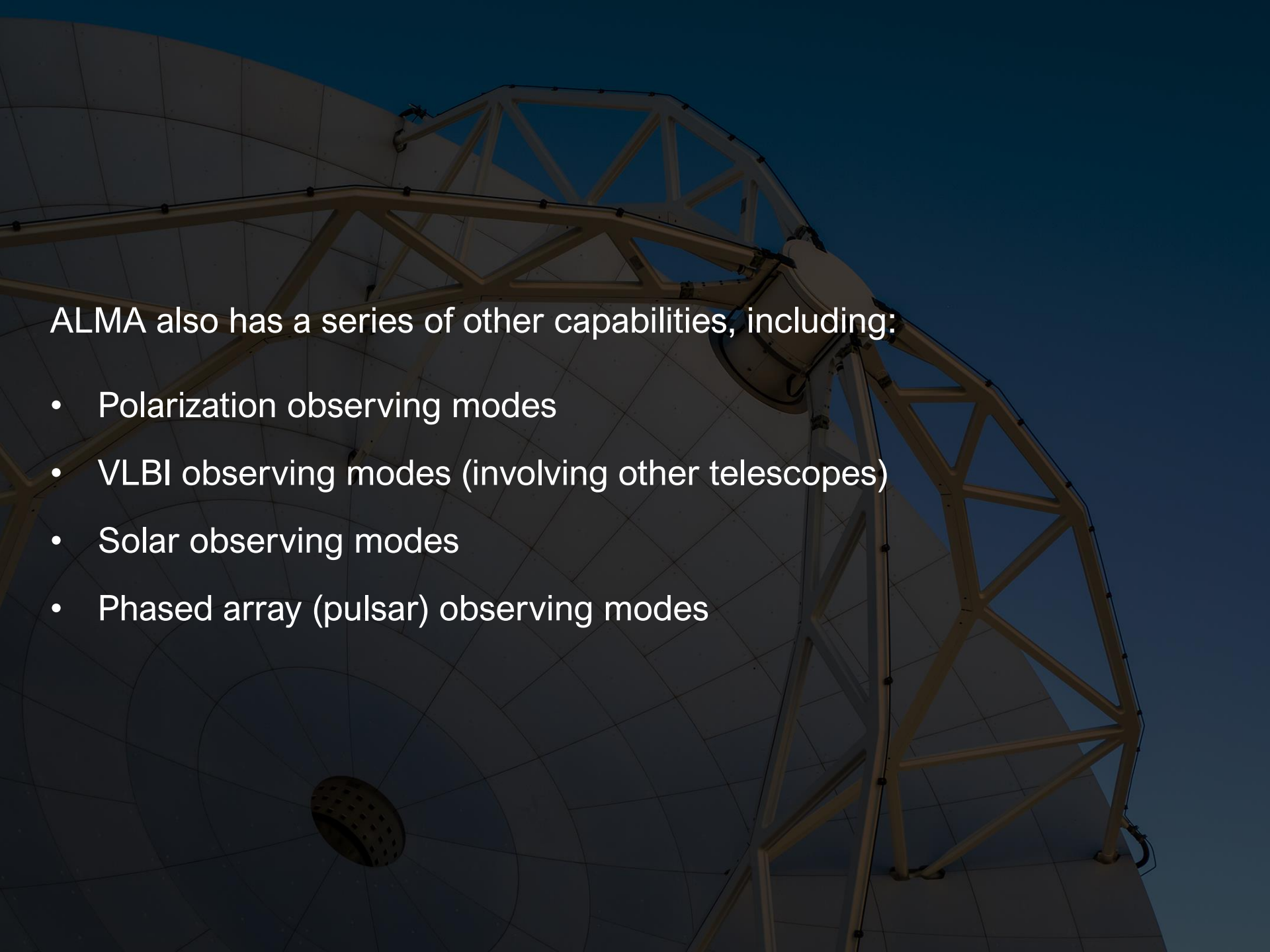




Also note that ALMA will be implementing the Wideband Sensitivity Upgrade (WSU) between now and 2030. This will increase the number of channels available per band by at least 2×.

This will have two key benefits:

- Continuum observations will be more efficient.
- Spectral scans will be faster.



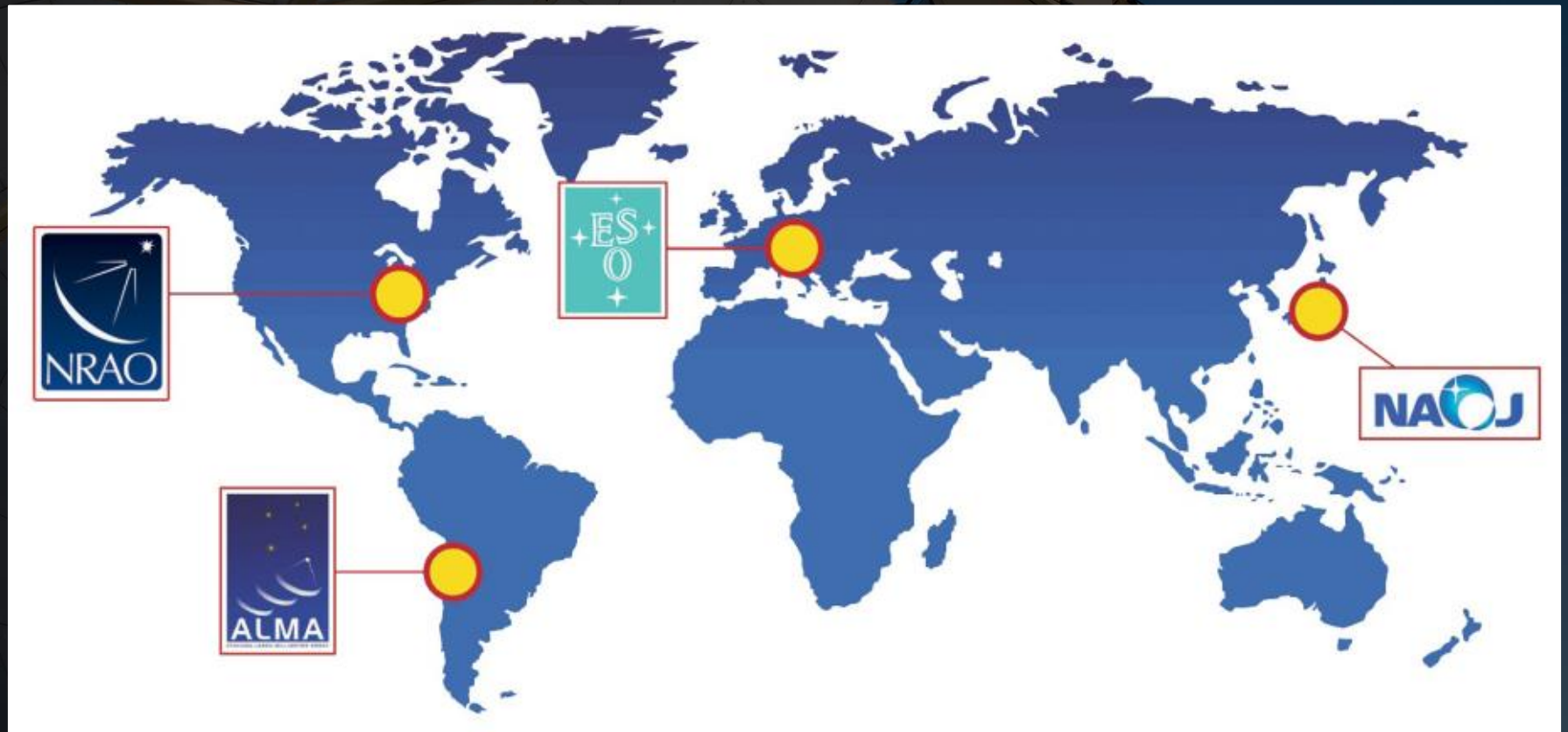
ALMA also has a series of other capabilities, including:

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



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 Observatory (JAO) in Chile coordinates all activities.

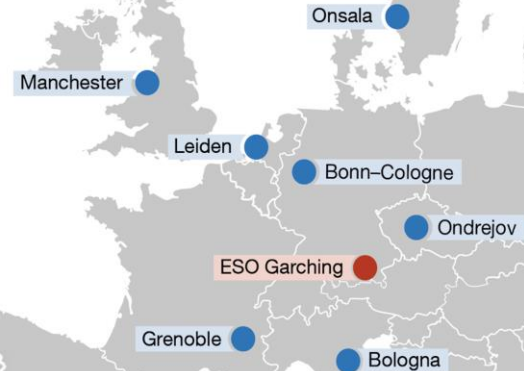


The European Southern Observatory coordinates ALMA activities in Europe.

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.

## European ARC Network





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

The screenshot shows the ALMA Observatory website homepage. The browser address bar displays <https://www.almaobservatory.org/en/home/>. The page features a dark blue header with the ALMA logo and navigation menu. The main content area is divided into several sections:

- Top Left:** ALMA logo and navigation menu with options for About ALMA, News, Outreach, Multimedia, ALMA for, ALMA at 10 years Conference, Scientists, Schools, and Media.
- Top Right:** A large image of a galaxy with a central bright spot, accompanied by a "Press Releases" section titled "Gas on the run – ALMA spots the shadow of a molecular outflow from a quasar when the Universe was less than one billion years old" dated 1 February, 2024. The text describes quasars as compact regions powered by supermassive black holes.
- Middle Left:** A "Press Releases" section with two images of black hole shadows, dated 2017 April 11 and 2018 April 21, with a date label of 18 January, 2024. The title is "M87\* One Year Later: Proof of a persistent black hole shadow".
- Middle Right:** A "The People" section titled "10 Years Transforming Together our Understanding of the Universe" dated 16 March, 2023, featuring logos for AOA, NAOJ (National Astronomical Observatory of Japan), and NRAO.
- Bottom:** A row of four small images, each with a "Press Releases" label, showing various astronomical phenomena.

The JAO has a webpage for professional astronomers at <https://almaobservatory.org/en/scientists>.

The screenshot shows a web browser window displaying the ALMA website. The browser's address bar shows the URL <https://www.almaobservatory.org/en/scientists/>. The website's header includes the ALMA logo and the text "Atacama Large Millimeter/submillimeter Array". A navigation menu on the left lists various sections, with "Scientists" highlighted in yellow. The main content area features a large banner for the "ALMA Conference" on "5 December, 2023", celebrating "10 years" of the observatory. Below the banner, the page is organized into several sections: "JAO", "JAO Science Team", and "Recent JAO Publications".

**ALMA** Atacama Large Millimeter/submillimeter Array

Eng Esp

- About ALMA
- News
- Outreach
- Multimedia
- ALMA for
  - ALMA at 10 years Conference
- Scientists**
- Schools
- Media

## JAO

The Joint ALMA Observatory (JAO), located in Santiago (Chile), provides the unified leadership and management for ALMA. JAO staff are responsible for maintaining and optimizing the performance of the Radio telescope and conducting observations on behalf of the astronomical community.

## JAO Science Team

The Science Team at the JAO is responsible for optimizing the scientific performance of ALMA, calibrating and imaging ALMA data, and conducting scientific research. The Science Team consists of both long-term staff members in the JAO Department of Science Operations and postdoctoral fellows.

## Recent JAO Publications

- December 31, 2023  
**BASS. XLII. The Relation between the Covering Factor of Dusty Gas and the Eddington Ratio in Nearby Active Galactic Nuclei**
- December 27, 2023  
**What Determines the Physical Size of a H<sub>2</sub>O Megamaser Disk?**



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 ALMA logo is displayed with the text "Atacama Large Millimeter/submillimeter Array" and "In search of our Cosmic Origins". A navigation menu includes links for About, Science, Proposing, Observing, Data, Processing, Tools, Documentation, and Help.

The main content area is divided into several sections:

- Science Highlight:** Titled "Protonated acetylene in the z=0.89 absorber toward PKS1830-211". It features two contour plots of the molecule. The left plot is labeled "Diidymos-Dimorphos 345 GHz Continuum" and the right plot is "Diidymos-Dimorphos + Ejecta 345 GHz Continuum". Below the plots is a paragraph describing the detection of a new interstellar molecule, protonated acetylene (C<sub>2</sub>H<sub>3</sub><sup>+</sup>), based on ALMA observations. It mentions that the molecule has been suspected to be present in the interstellar medium for a long time but has eluded detection due to unfavourable frequencies of its rotational spectrum. The text concludes with "detected in ALMA high-sensitivity spectra. As one of the initial hydrocarbon building..." and a "More..." link.
- Observatory News:** A list of recent news items including "Announcement for early proposal planning for Cycle 11" (Dec 20, 2023), "Restart of the Cycle 10 antenna relocations" (Dec 05, 2023), "Announcement from ALMA director on observatory priorities during WSU implementation" (Nov 20, 2023), "Release of Science Verification Data for W51 in Band 1" (Nov 06, 2023), and "Release of Solar Full Polarization ALMA Test Data" (Nov 06, 2023). A "More..." link is provided at the bottom.
- EU ARC News:** A list of news items including "Upcoming workshop 'The promises and challenges of the ALMA Wideband Sensitivity Upgrade'" (Jan 10, 2024), "Postdoctoral Researcher for an ALMA ADP pipeline" (Dec 22, 2023), "European ALMA school" (Oct 25, 2023), "At the Allegro node: ALMA Data Reduction Training Day on 27 November 2023" (Oct 21, 2023), and "Postdoctoral position(s) at the Allegro ARC node at". A "More..." link is provided at the bottom.
- ALMA Status:** A section titled "Configuration Schedule" showing "Retired publications: 3641", "Last observed source: NGC\_7252E", and "Current configuration: C-3". A "More..." link is provided at the bottom.

At the bottom of the page, there is a "Quick Links" table:

<a href="#">ALMA Basics</a>	<a href="#">Configuration Schedule</a>
<a href="#">ALMA Science</a>	<a href="#">SnooPI</a>
<a href="#">ALMA Primer</a>	<a href="#">DDT Proposals</a>

The footer contains links for "Site Map", "Accessibility", "Contact", and "Privacy Statement", along with a "Region:" dropdown menu set to "EA", with "EU" and "NA" options also visible.

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 displaying the UK ALMA Regional Centre website. The browser's address bar shows the URL <https://www.alma.ac.uk>. The website header features the title "UK ALMA Regional Centre" and a banner image of the ALMA observatory with the text "EUROPEAN ARC ALMA Regional Centre || UK".

On the left side, there are three main navigation sections:

- 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

The main content area features a video player titled "Meet the UK ARC Node". The video thumbnail shows a complex network of blue lines representing the ALMA array, with the text "The UK ALMA Regional Centre Node" and a red play button. Below the video, it says "Watch on YouTube" and "Video Credit: Ana A. Alpizar".

Below the video is a news article titled "ALMA Creates New Images with Unprecedented Angular Resolutions". The article's thumbnail image shows a colorful, multi-lobed astronomical object against a dark background.



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

The screenshot displays the ALMA Science Archive interface. On the left, there is a spectral plot showing intensity versus frequency (100-900 GHz) with various molecular lines identified. On the right, a table lists observations with columns for Project code, ALMA source name, RA, Dec, Band, Cont. sens., Frequency support, Release date, Publications, and other parameters.

**Molecules and Lines:**

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

**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
2011.0.00191.5	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
2011.0.00131.5	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
2011.0.00101.5	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
2011.0.00397.5	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
2011.0.00397.5	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
2011.0.00397.5	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
2011.0.00397.5	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
2011.0.00397.5	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
2011.0.00397.5	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
2011.0.00397.5	J064228.93-272801.8	06:42:28.930	-27:28:01.800	7	0.5346	337.008-352.993 GHz	2012-12-20	3	1.165	26.541	12m		8.123

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

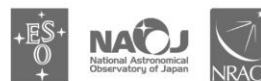
The screenshot shows a web browser window with the URL <https://help.almascience.org>. The page header includes the ALMA logo and the text "Atacama Large Millimeter/submillimeter Array Observer Support". A navigation bar contains "ALMA Science" and a "Submit Helpdesk Ticket" button. A search bar with the placeholder text "How can we help you today?" is centered below the header. A secondary navigation bar includes "Help Center", "TOO", and "Search Sci Portal". 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). Below these tiles is a white box with the text "Welcome to the ALMA Helpdesk". At the bottom left, there is a "News" section with a notification icon.



## Observing with ALMA – A Primer (Cycle 11)

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



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

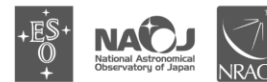
ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), NSTC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ.

## ALMA Cycle 11 Proposer's Guide



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

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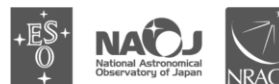
## ALMA Cycle 11 Technical Handbook



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

## 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>.



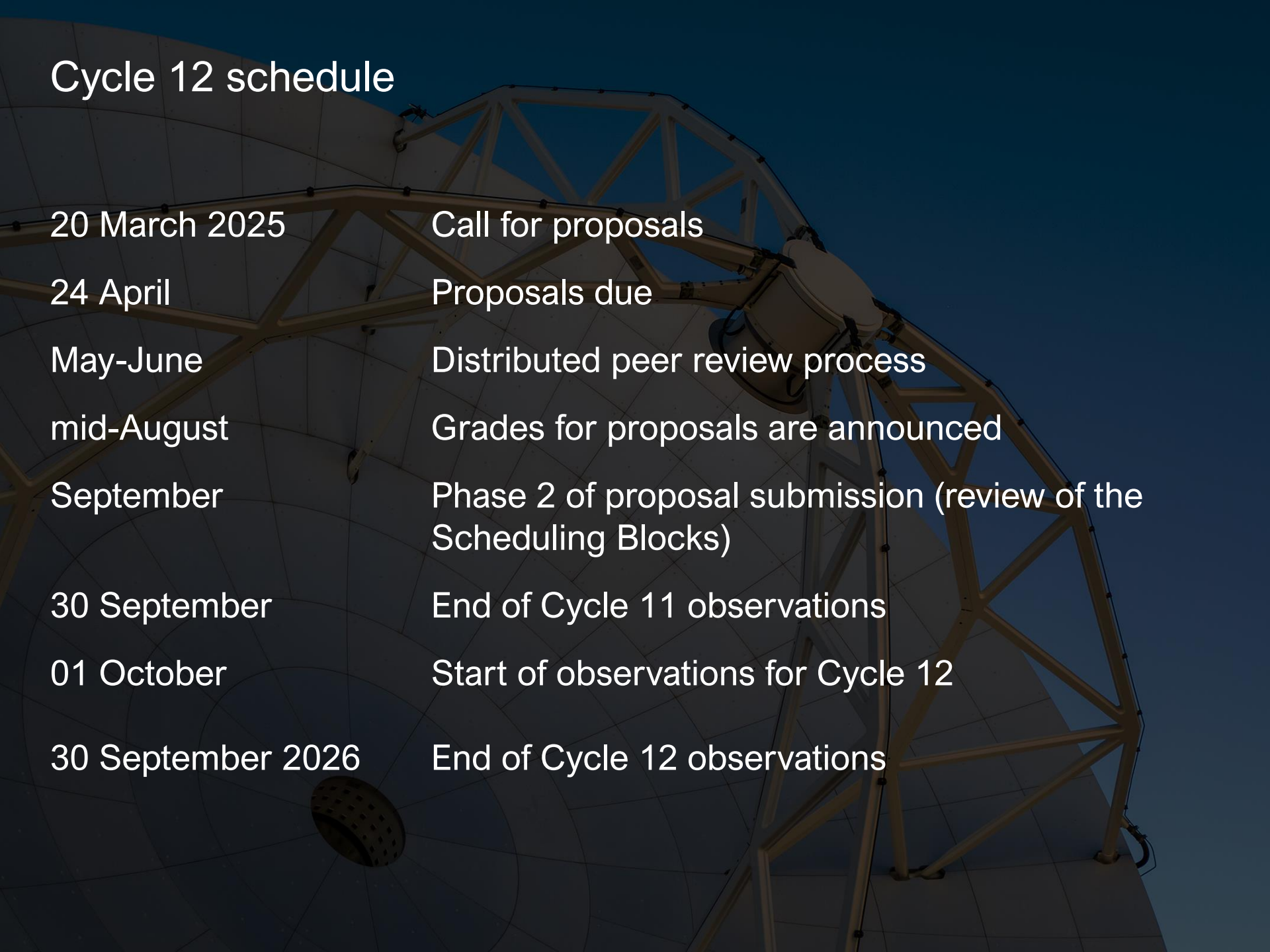
[www.almascience.org](http://www.almascience.org)

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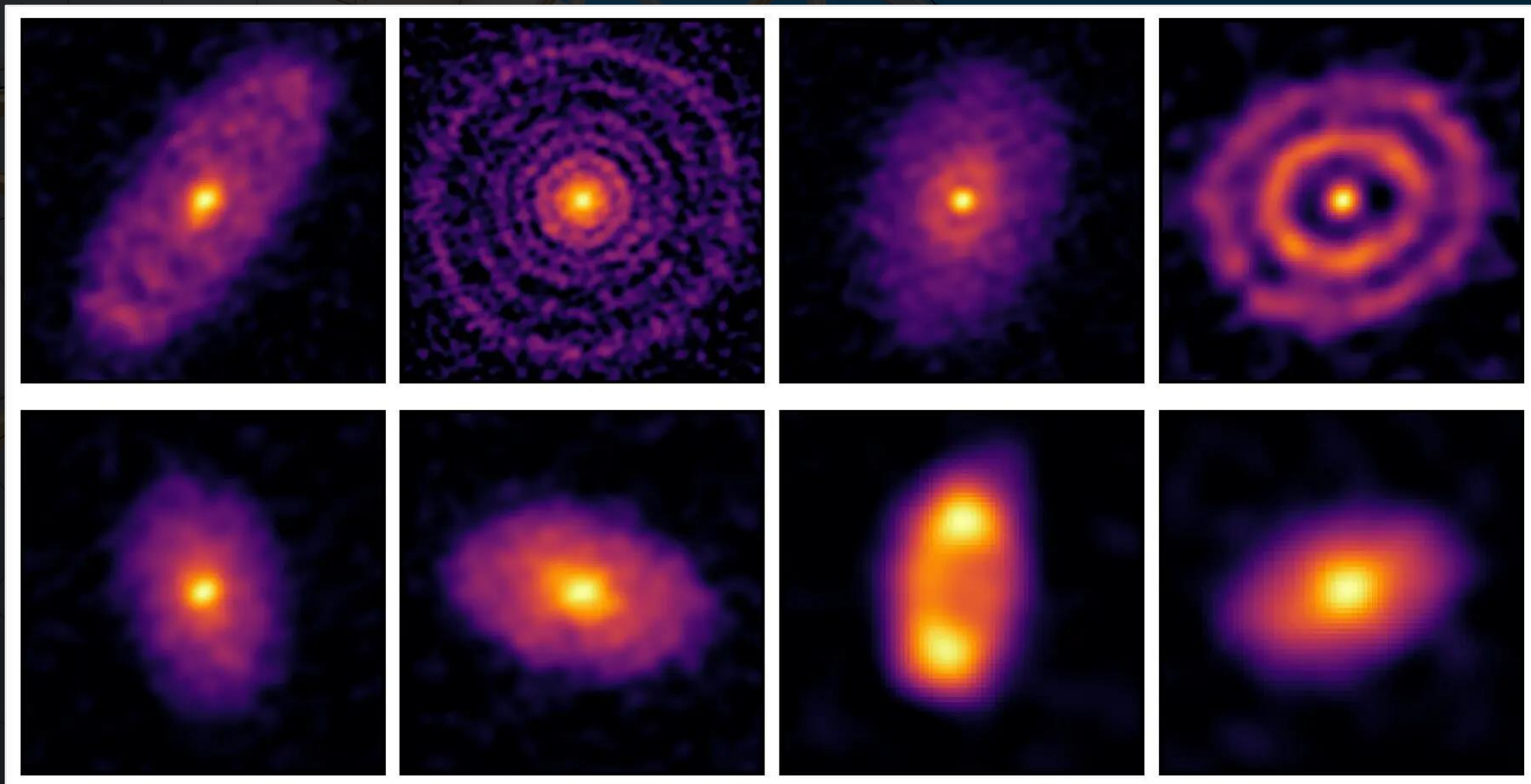
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# Cycle 12 schedule



20 March 2025	Call for proposals
24 April	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 11 observations
01 October	Start of observations for Cycle 12
30 September 2026	End of Cycle 12 observations



Protostellar disks in the Sigma Orionis Cluster.

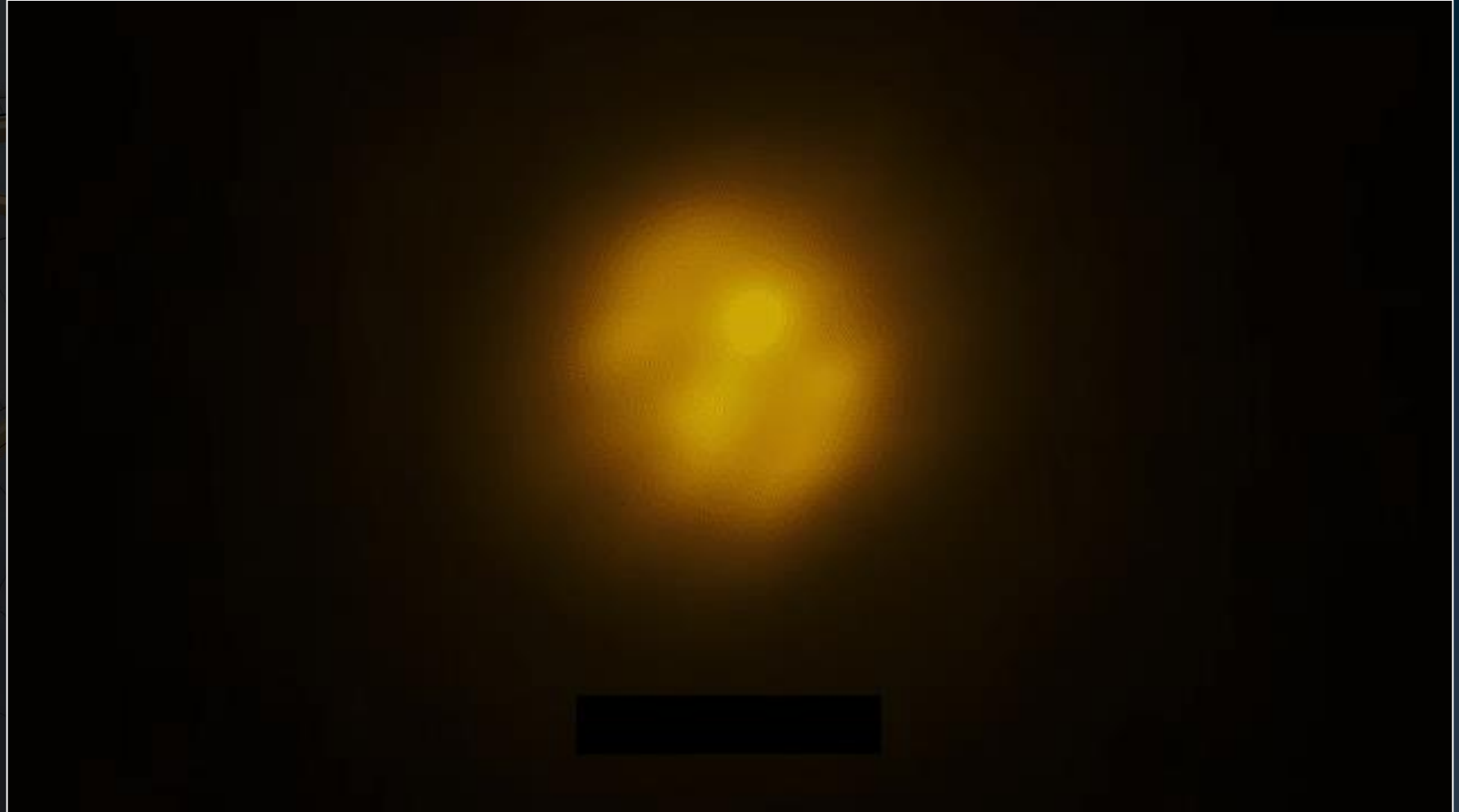
(Credit: ALMA (ESO/JAO/NAOJ/NRAO), J. Huang et. al.)





WL 20

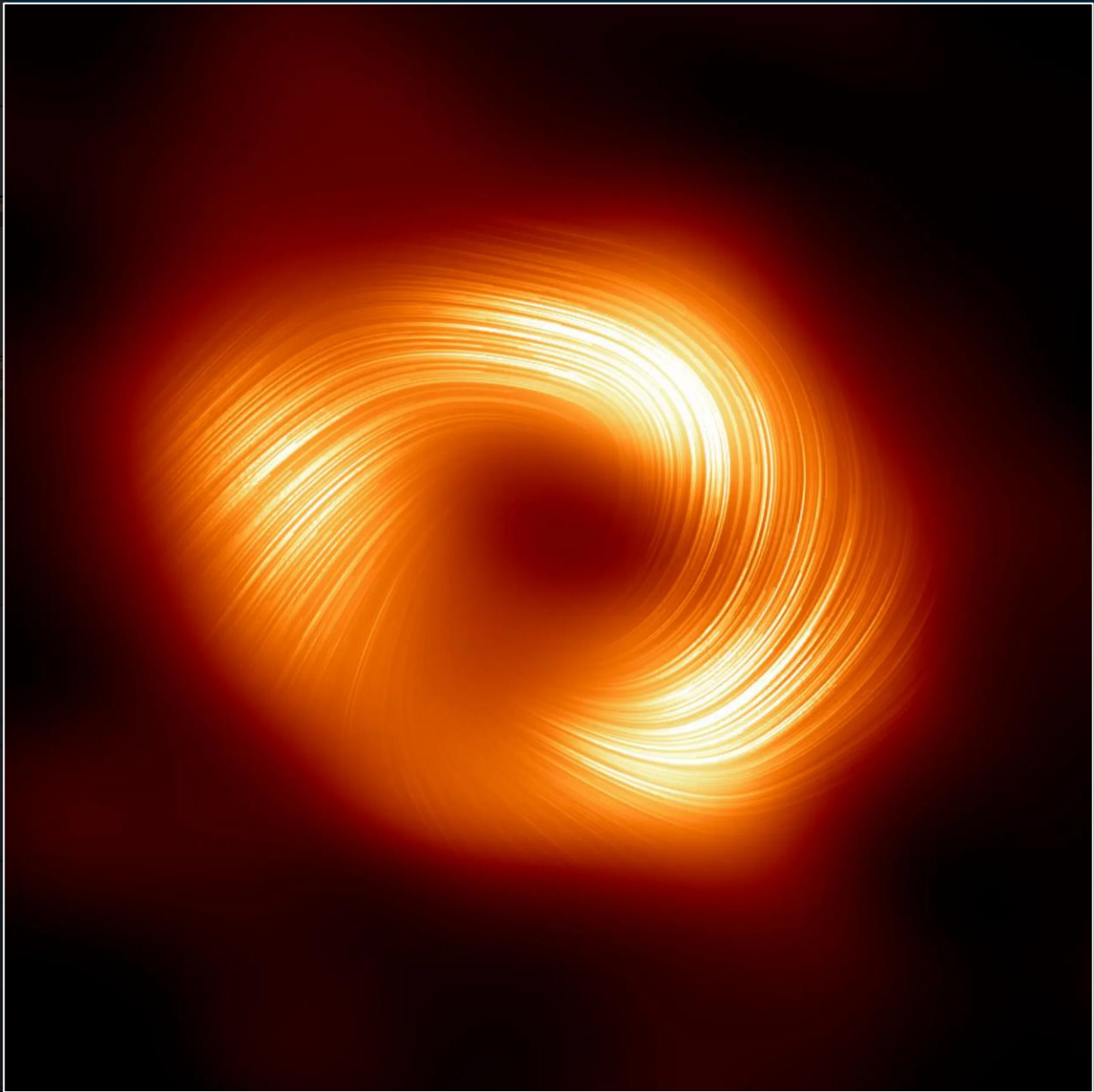
(Credit: U.S. NSF/ NSF NRAO/B. Saxton.; NASA/JPL-Caltech/Harvard-Smithsonian CfA)



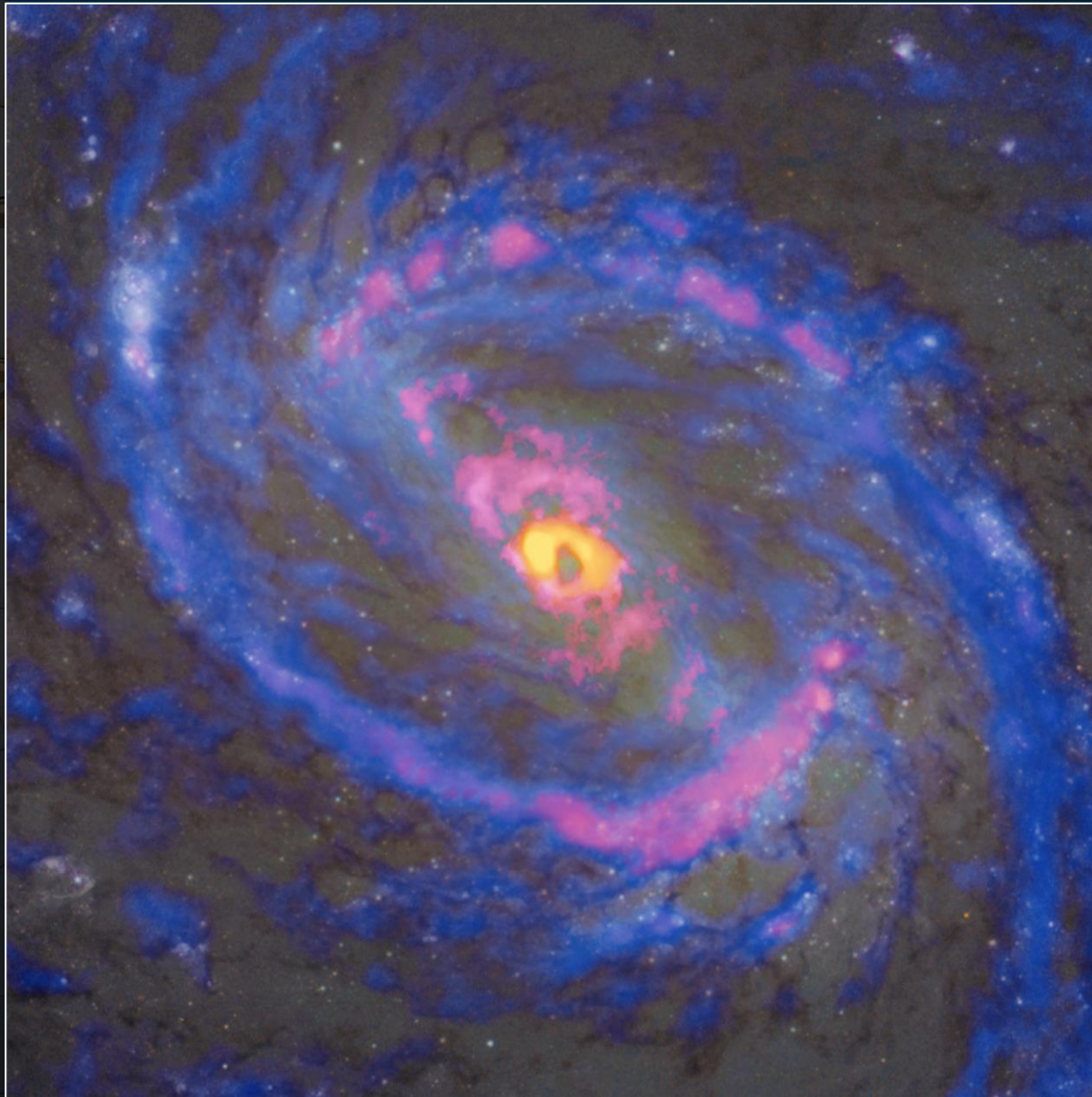
## R Doradus

(Credit: ALMA (ESO/NAOJ/NRAO)/W. Vlemmings et al.)





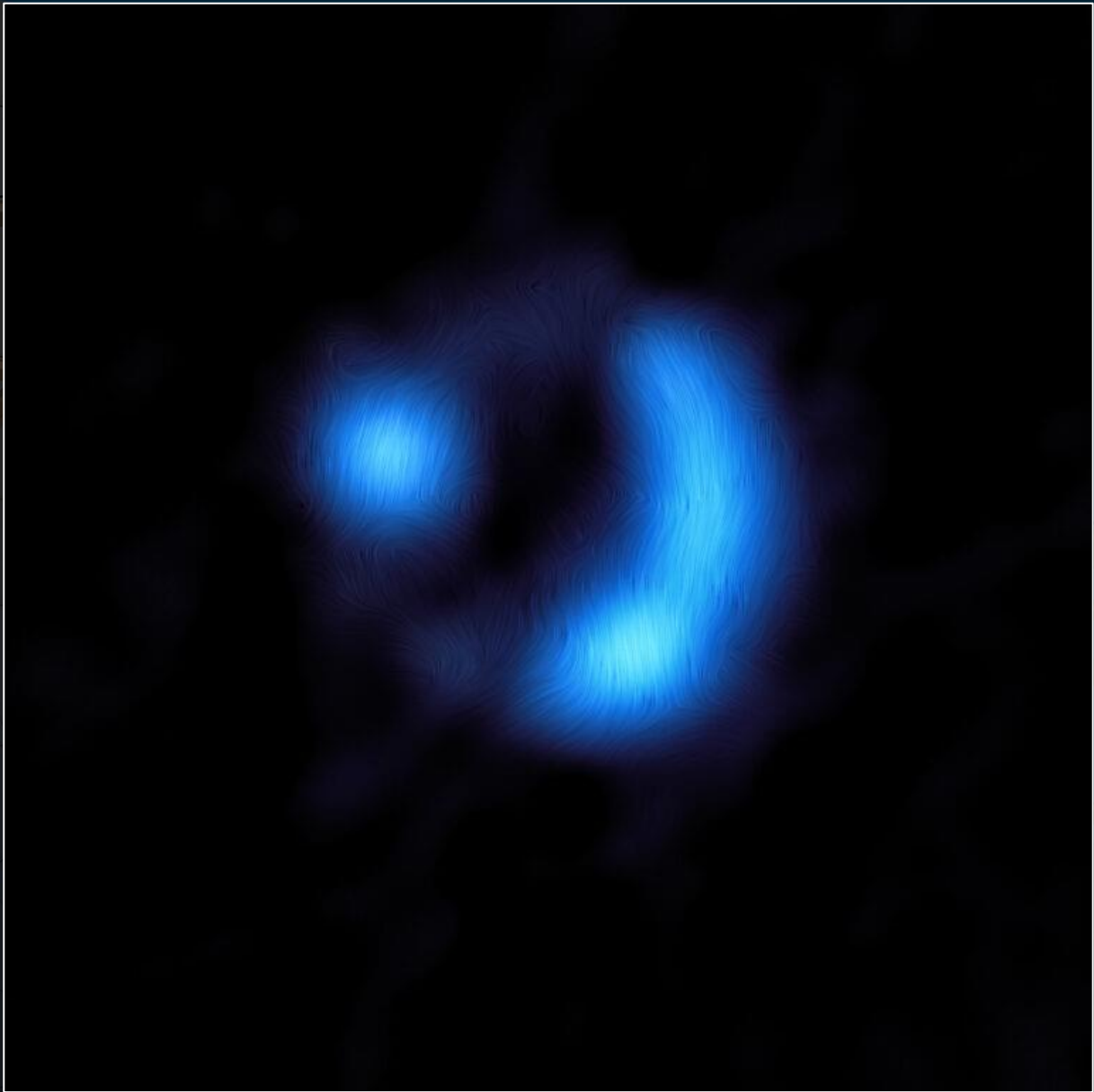
Sgr A\*  
(Credit: EHT Collaboration)



NGC 1068

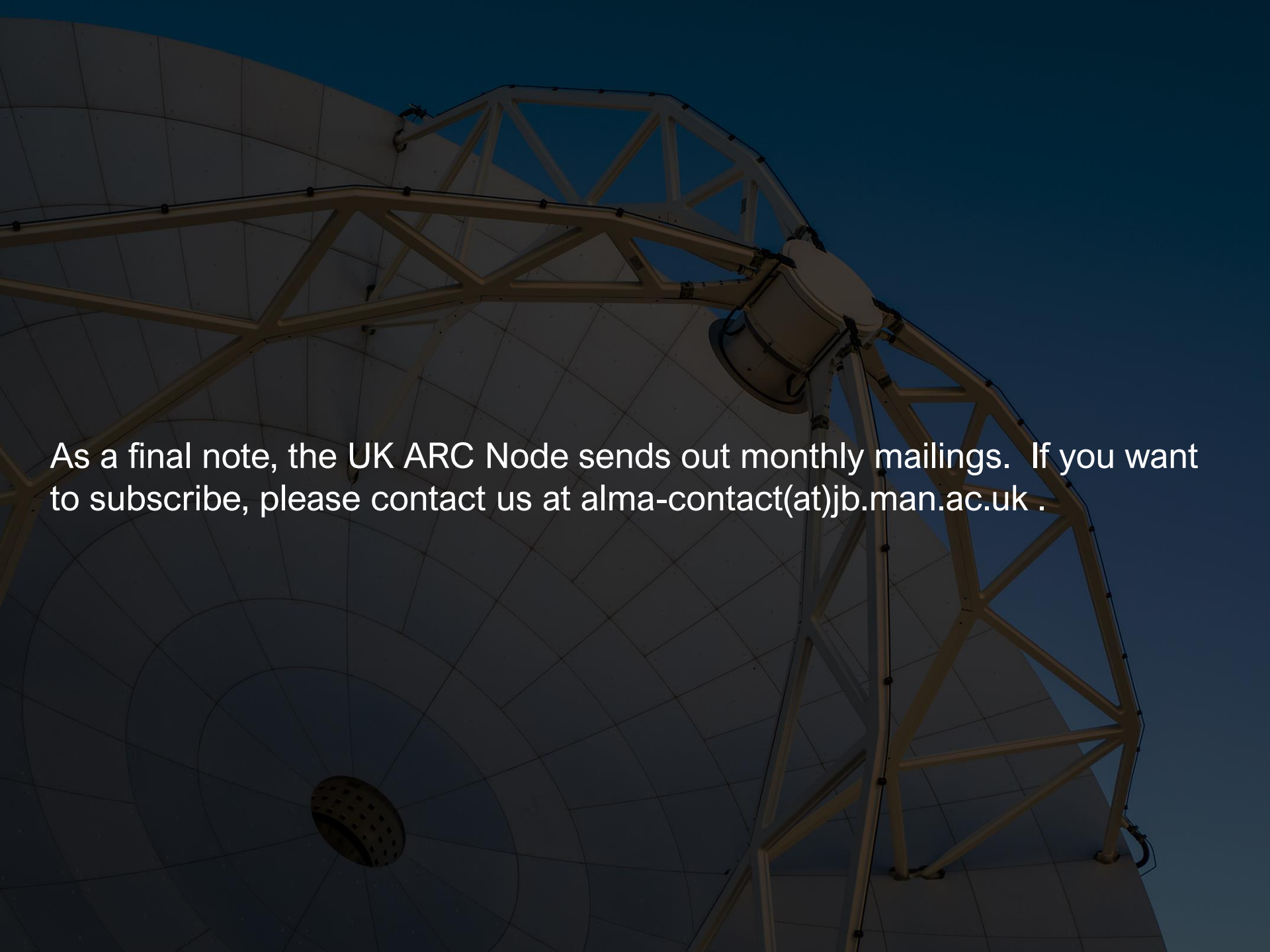
(Credit: ALMA (ESO/NAOJ/NRAO), NASA/ESA Hubble Space Telescope, T. Nakajima et al.)





9109

(Credit: ALMA (ESO/NAOJ/NRAO)/J. Geach et al.)

A large satellite dish antenna structure is shown against a dark blue sky. The dish is composed of a complex metal lattice of beams and supports. A large, circular, perforated antenna horn is visible on the right side of the structure. The dish itself is a large, curved surface with a grid pattern. The overall scene is dimly lit, suggesting dusk or dawn.

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