

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.

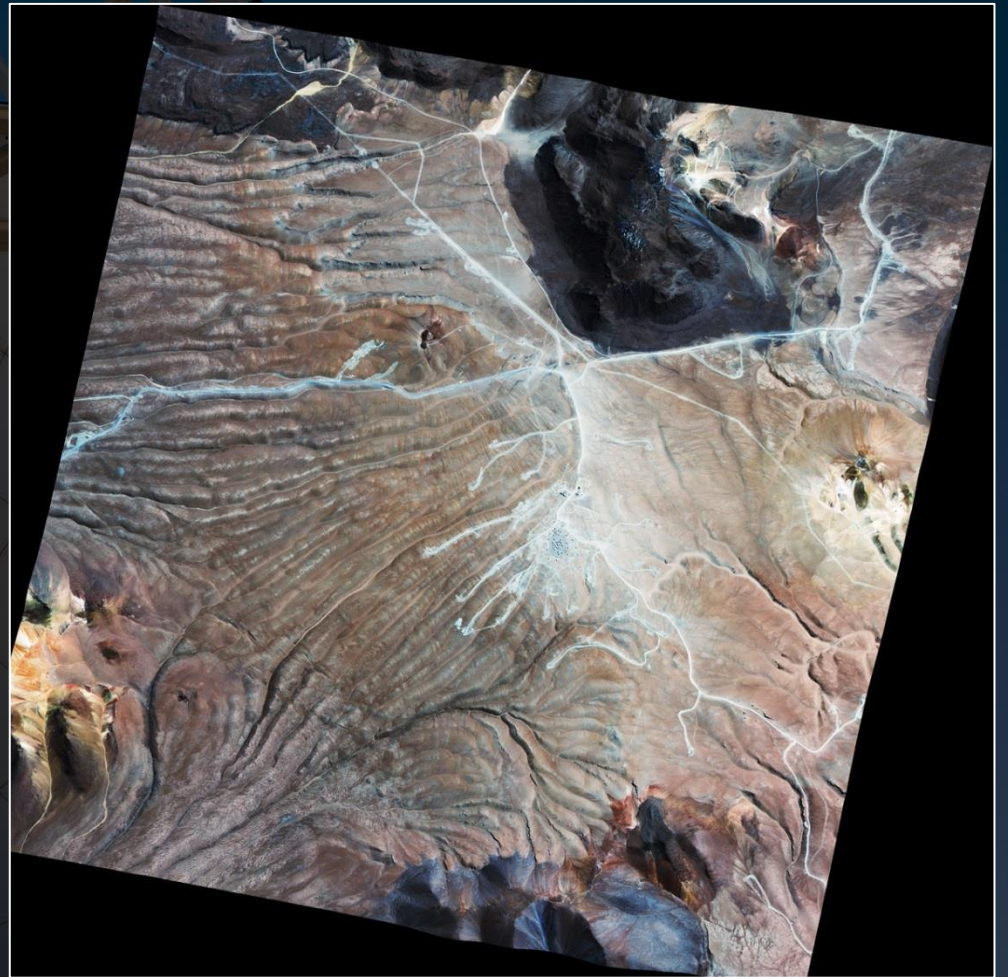


Some of the science performed with ALMA includes:

- 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

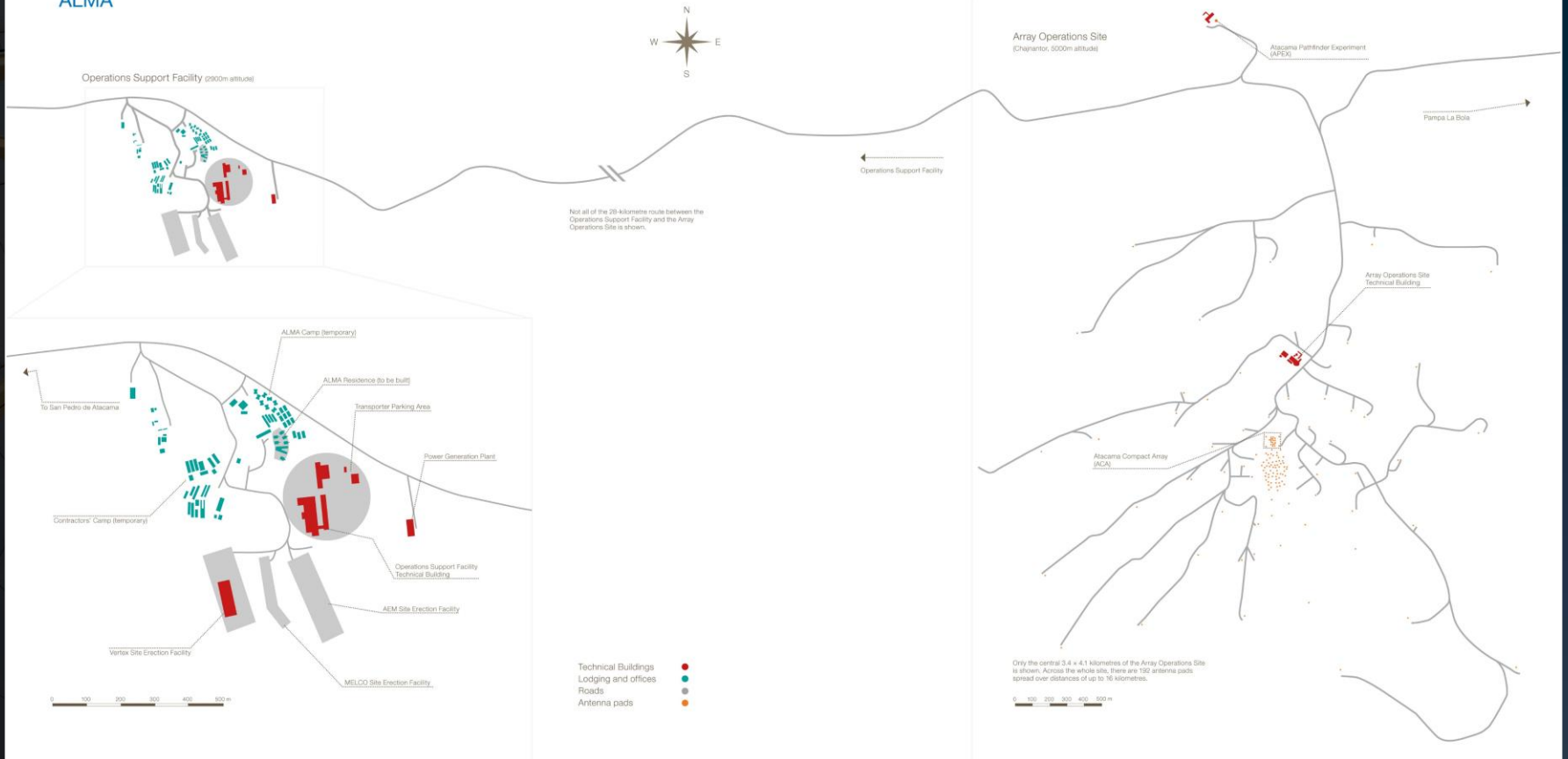
ALMA is located in the Atacama Desert, a high-altitude desert in Chile.

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



(Credit: Aerophotogrammetry 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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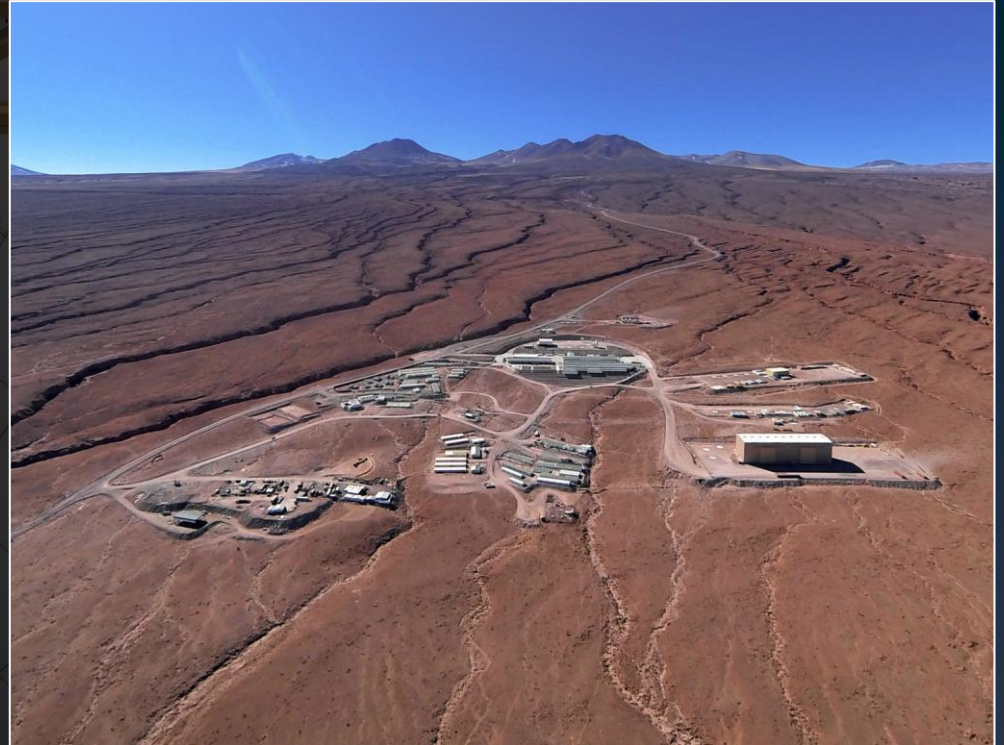
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(Credit: ESO/S. Fandango)

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.



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

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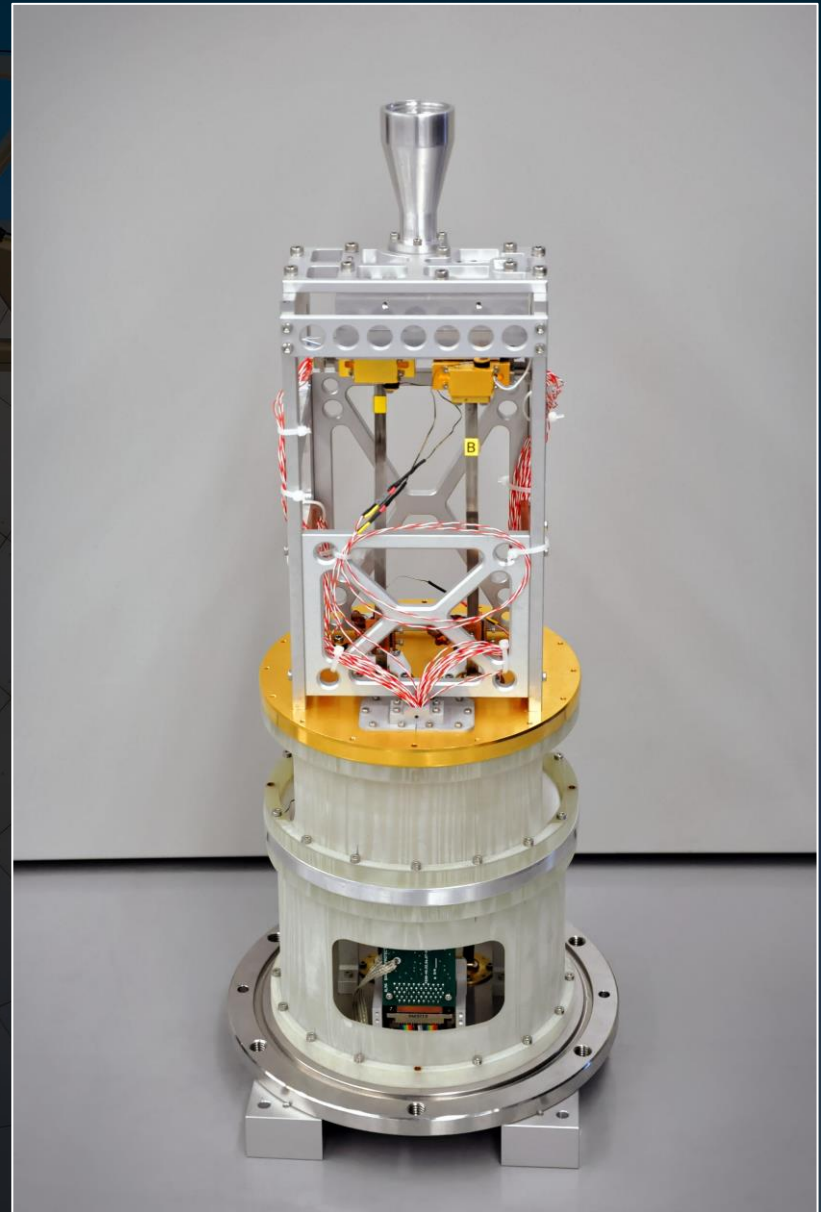
ALMA operations are managed from the Joint ALMA Office on the European Southern Observatory campus in Santiago.



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

ALMA uses multiple sets of heterodyne receivers.

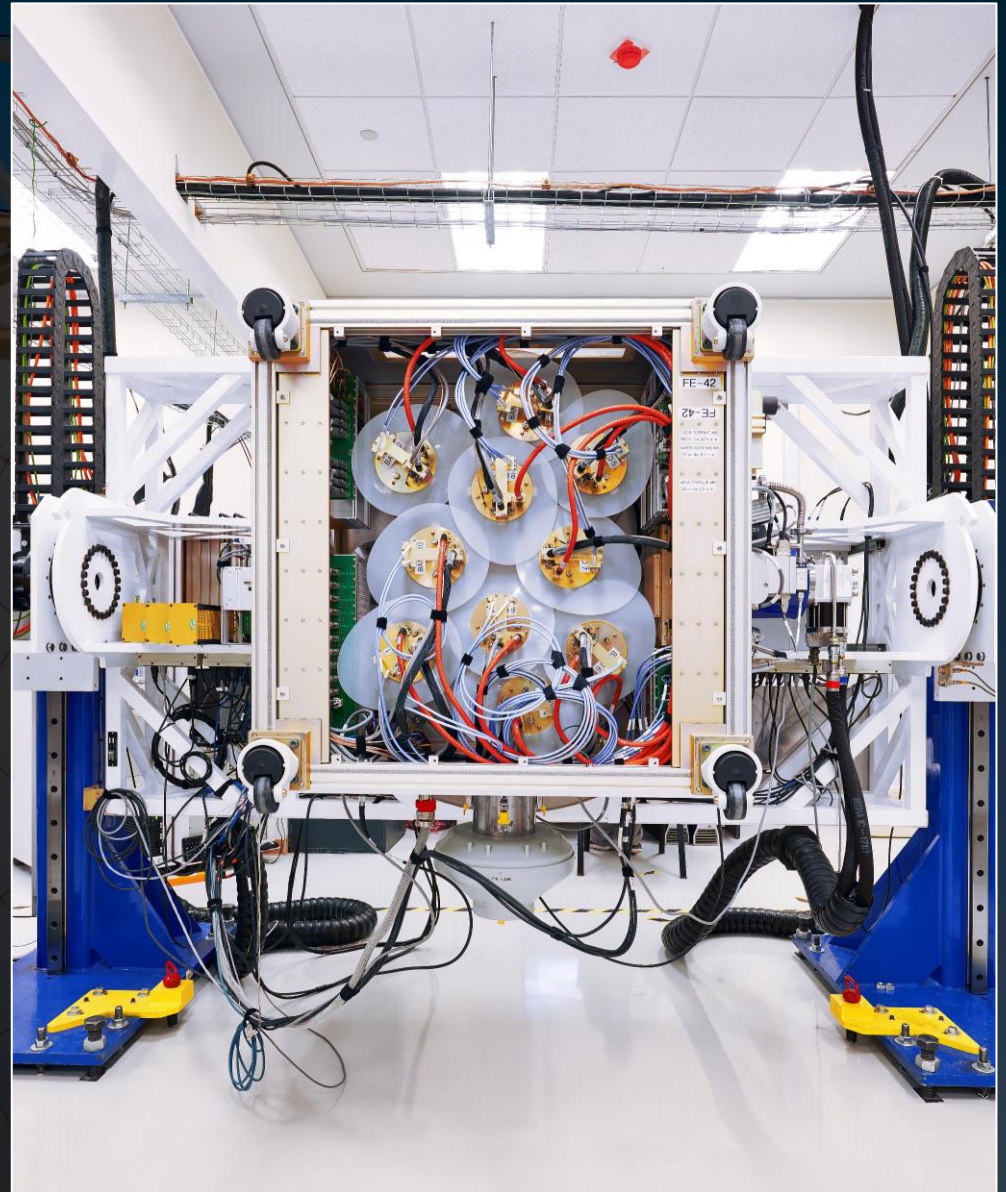
9 bands are available in Cycle 10.



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

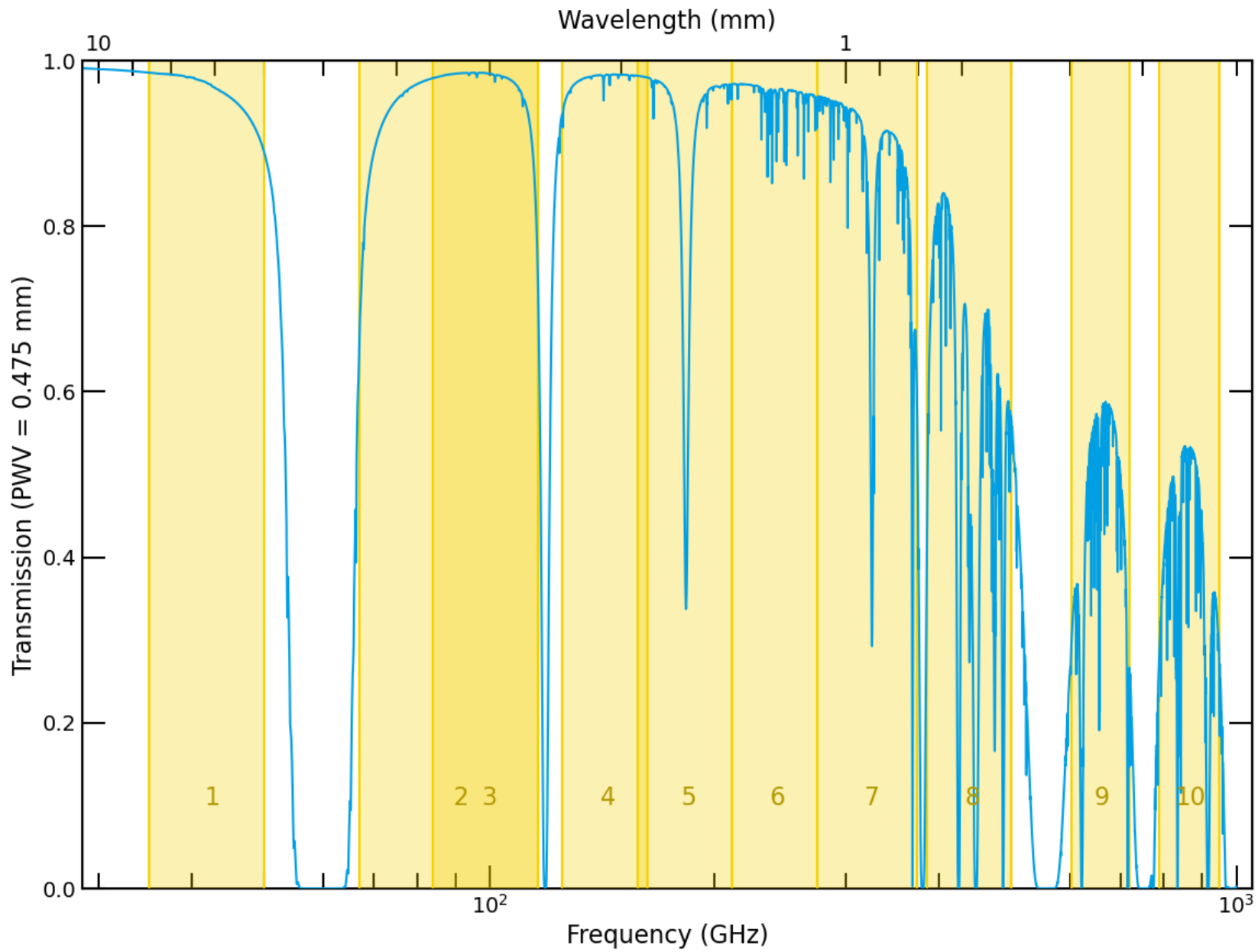
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9 bands are available in Cycle 10.



(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 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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(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.

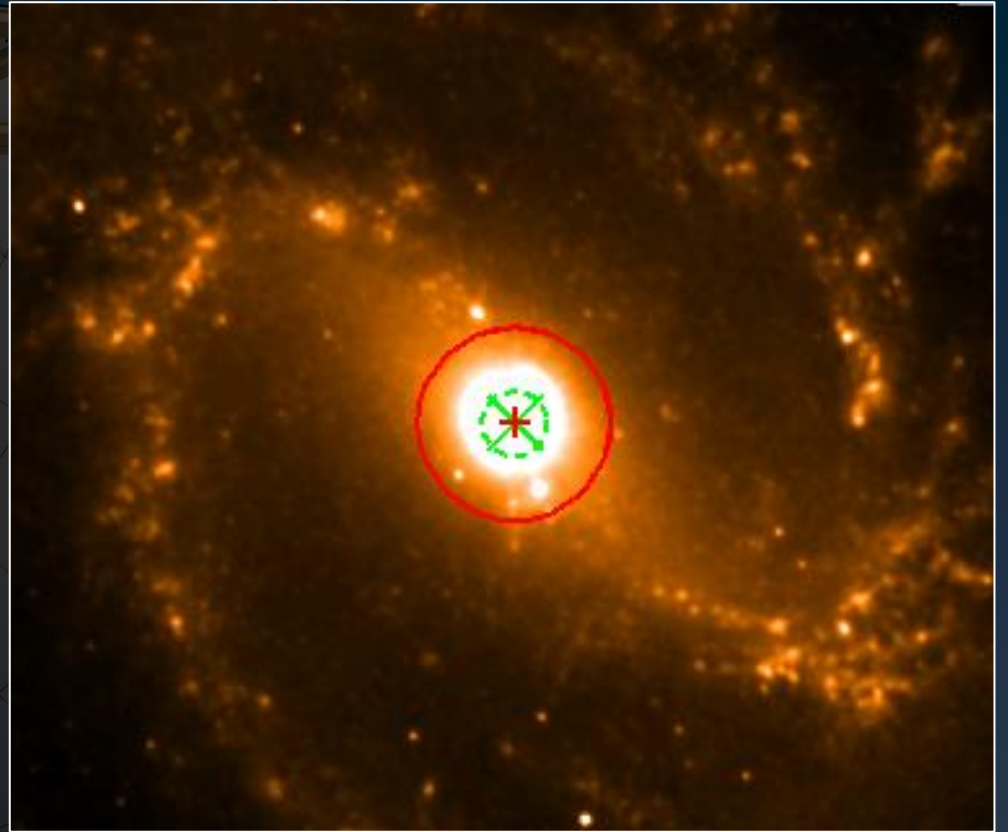


The total power antennas are used to detect large-scale line emission resolved out by both the 12m and ACA arrays. (Continuum-imaging capabilities may be added in the future.)



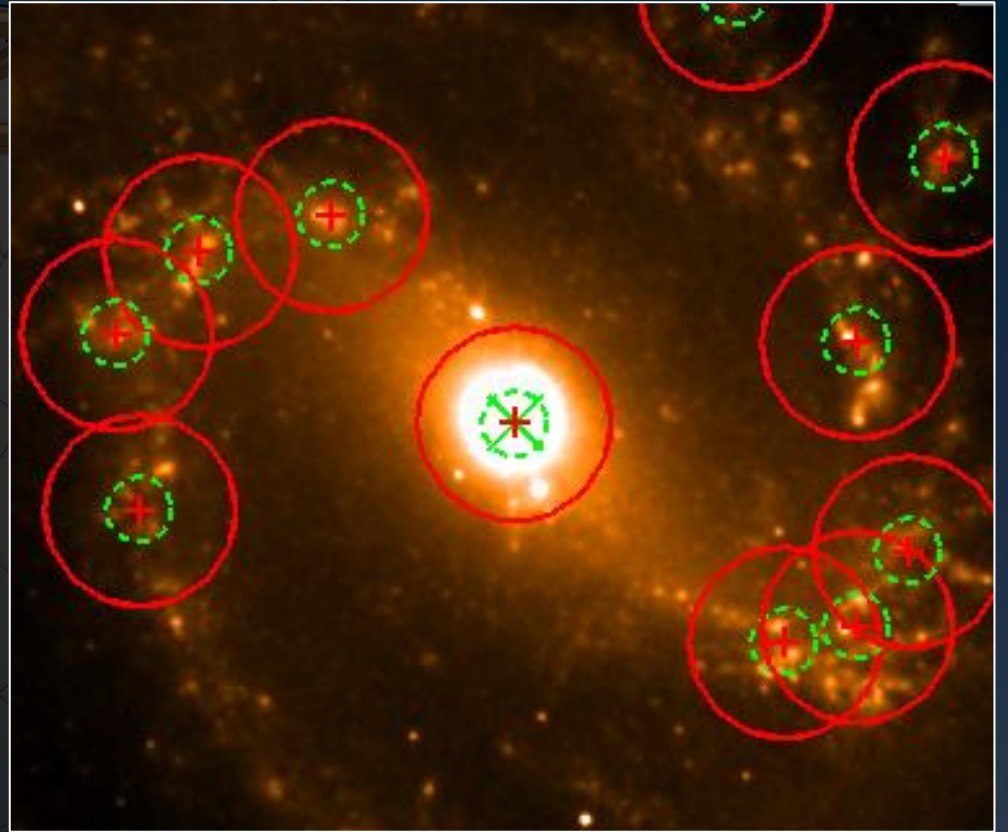
The most basic field that can be imaged by ALMA is a single pointing.

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



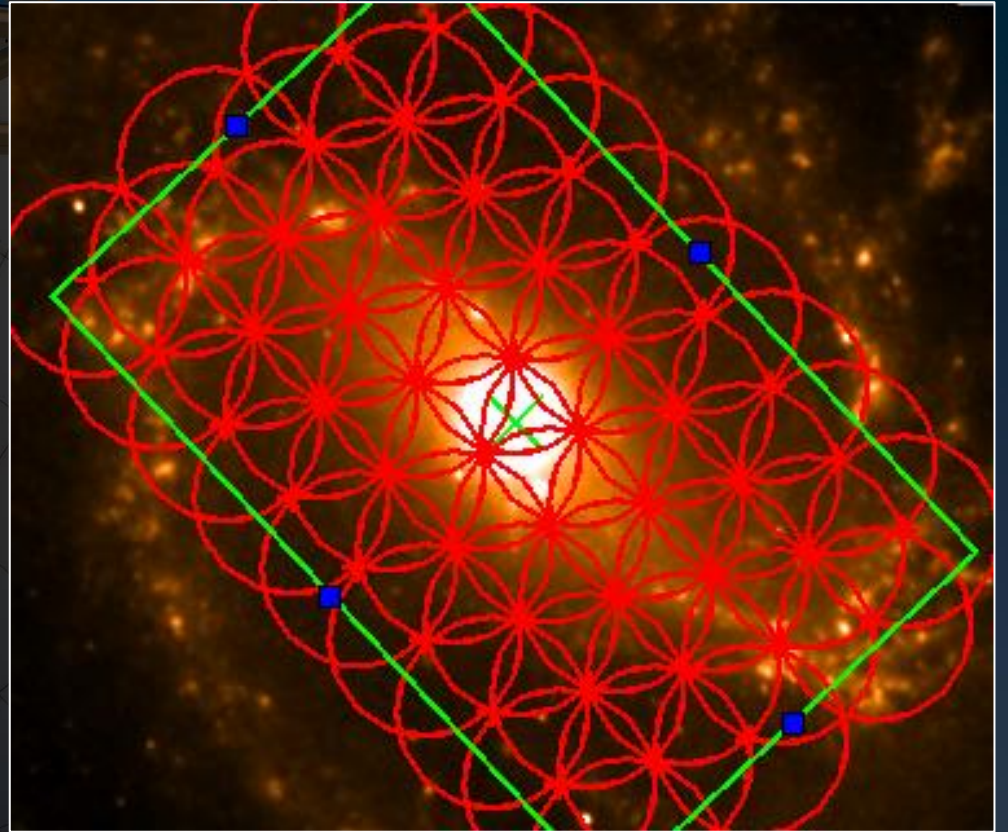
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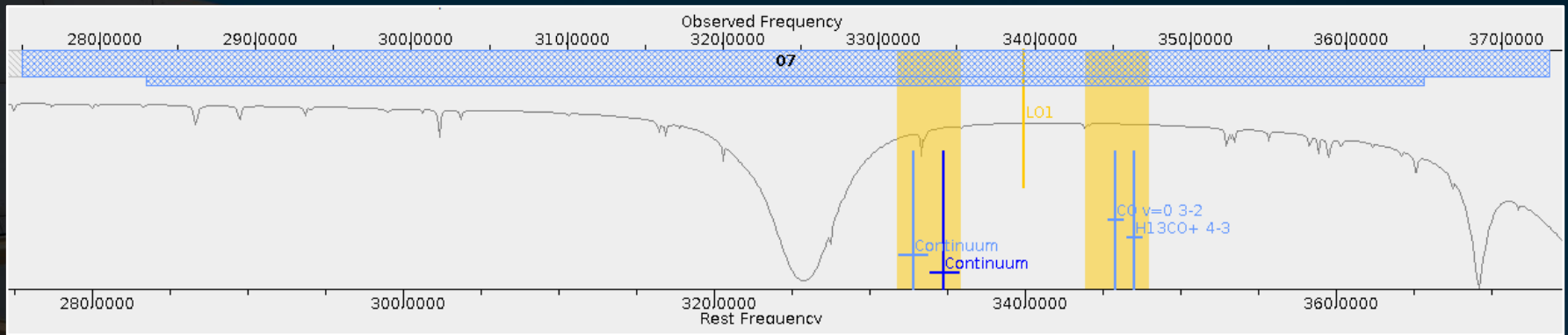
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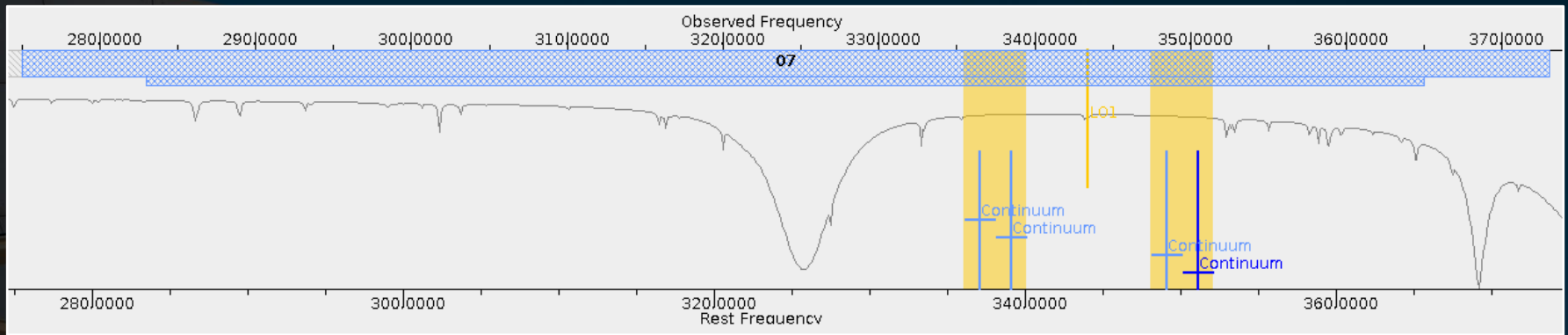


ALMA currently offers three types of spectral set-ups.

- 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).

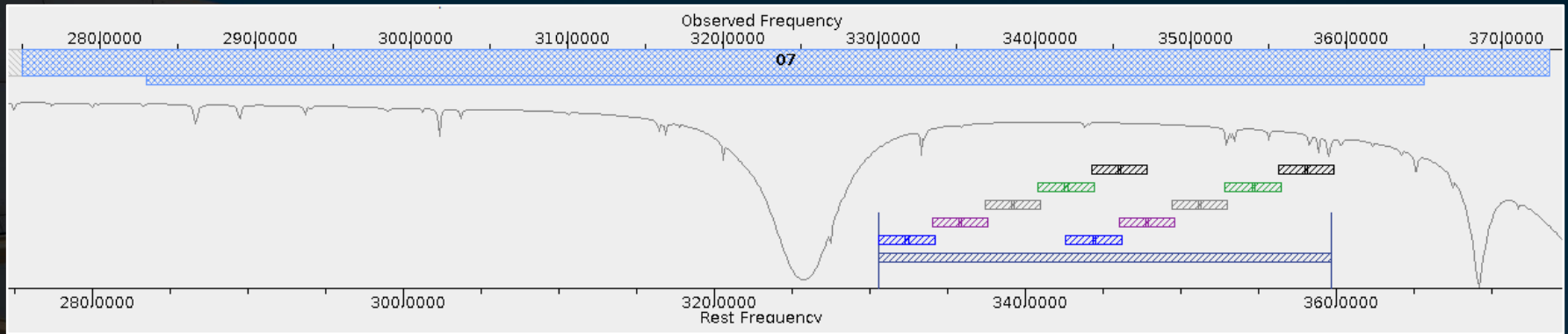


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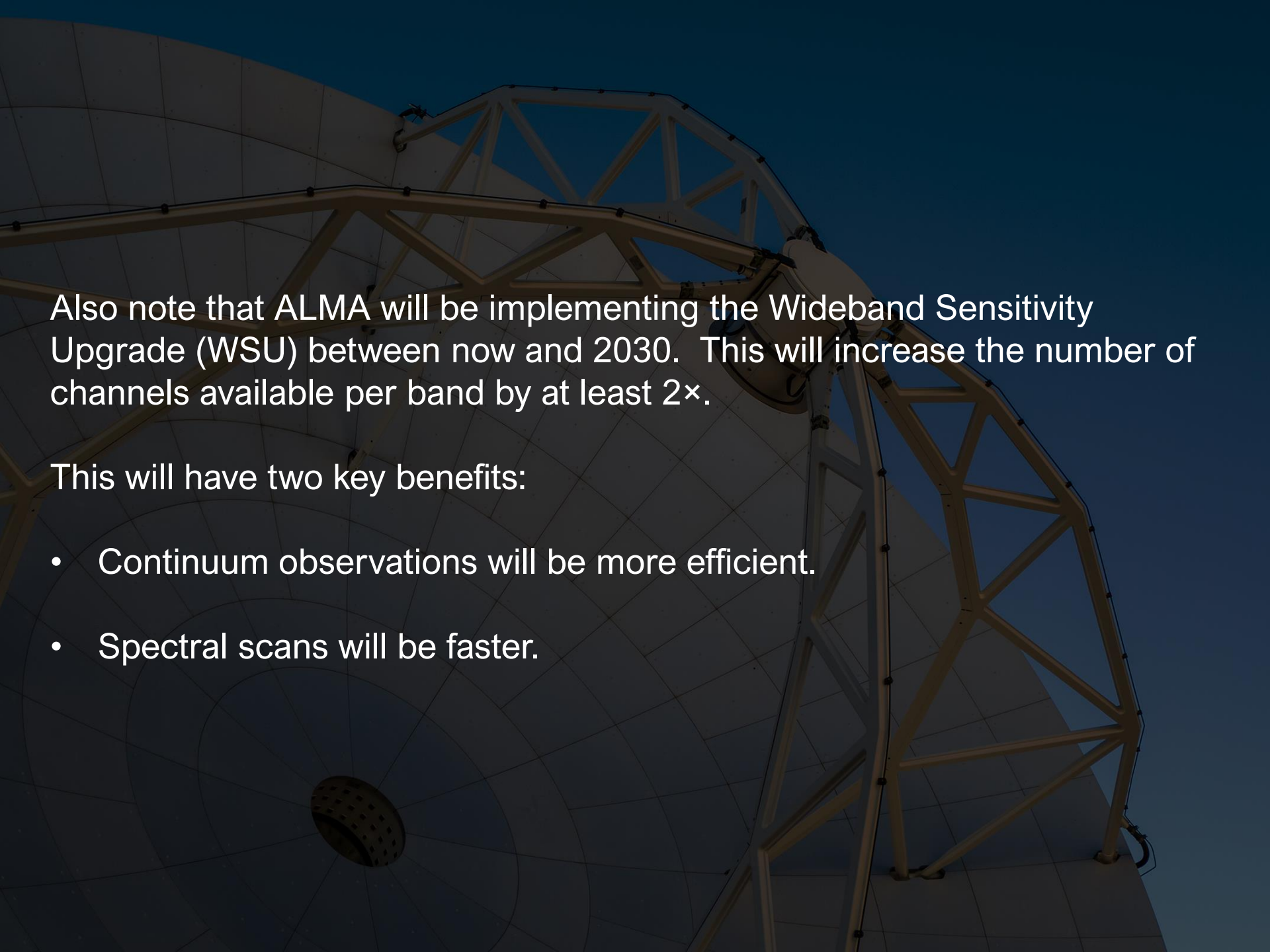


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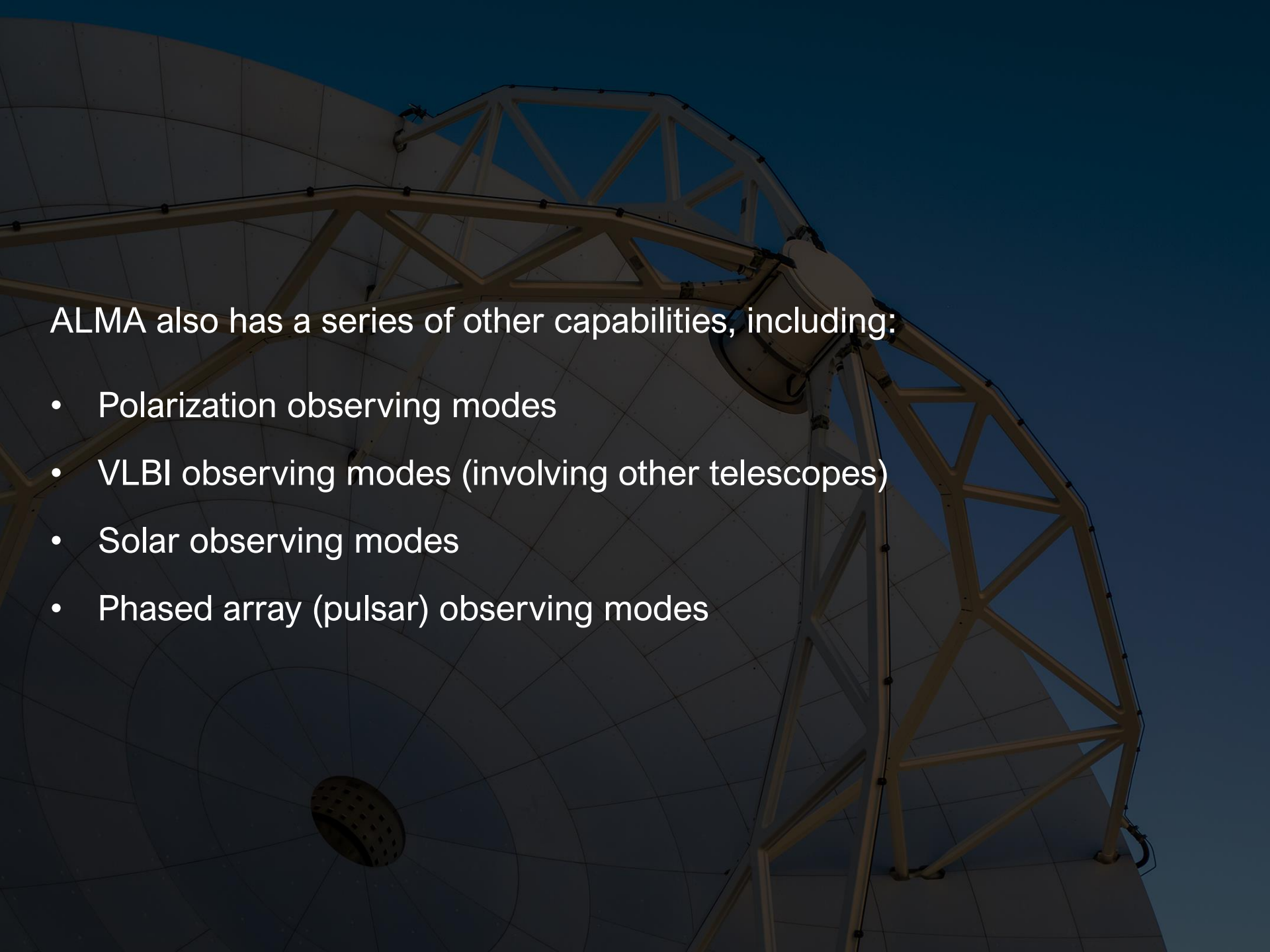
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Also note that ALMA will be implementing the Wideband Sensitivity Upgrade (WSU) between now and 2030. This will increase the number of channels available per band by at least 2×.

This will have two key benefits:

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

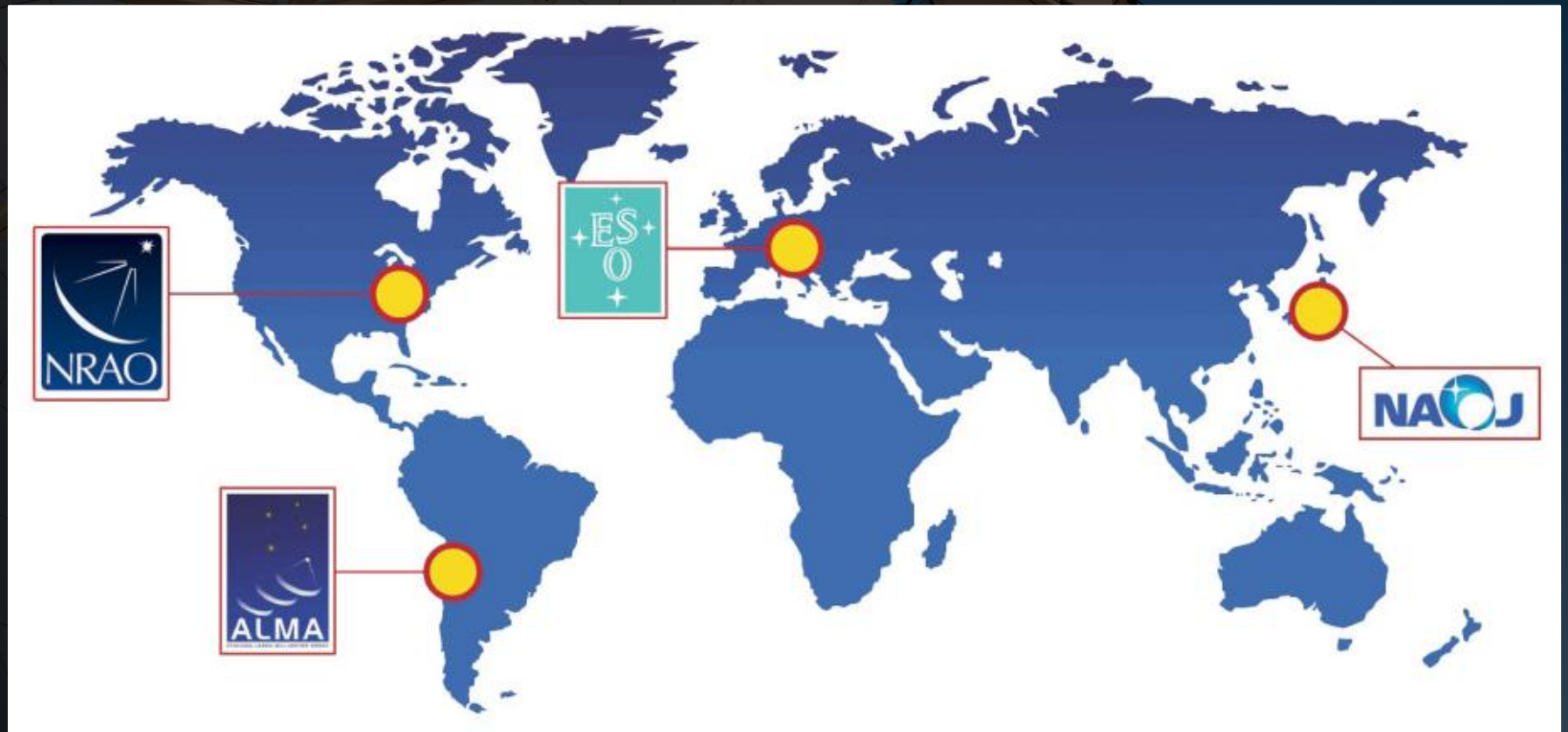


ALMA also has a series of other capabilities, including:

- 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 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.

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 the text "Atacama Large Millimeter/submillimeter Array". A navigation menu on the left includes links for "About ALMA", "News", "Outreach", and "Multimedia", as well as "ALMA for" sub-sections like "ALMA at 10 years Conference", "Scientists", "Schools", and "Media".

The main content area is dominated by a large image of a galaxy. To its right, a "Press Releases" section highlights a recent article: "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 below the headline reads: "A quasar is a compact region powered by a supermassive black hole located in the center of a massive galaxy. They are extremely luminous, with a point-like appearance similar to stars, and are extremely distant from Earth. Owing to their distance and brightness, they provide a peek into conditions of the early Universe, when it..."

Below the main image, there are two smaller featured articles. The first, dated "18 January, 2024", is titled "M87* One Year Later: Proof of a persistent black hole shadow" and features two images of the black hole shadow. The second, dated "16 March, 2023", is titled "10 Years Transforming Together our Understanding of the Universe" and features logos for ALMA, NAOJ (National Astronomical Observatory of Japan), and NRAO.

At the bottom of the page, there are three more "Press Releases" thumbnails showing various astronomical images, including galaxies and planetary systems.

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

Scientists | ALMA | ALMA

Atacama Large Millimeter/submillimeter Array

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About ALMA

News

Outreach

Multimedia

ALMA for

ALMA at 10 years Conference

Scientists

Schools

Media

10 years

All Science Highlights
ALMA Conference
5 December, 2023

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 H₂O 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". Below the logo is a navigation menu with 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 labeled "Diidymos-Dimorphos + Ejecta 345 GHz Continuum". Both plots show contours of the molecule's emission against a background of the quasar PKS1830-211. Below the plots is a paragraph describing the detection of the molecule and its significance in the interstellar medium.
- Observatory News:** A list of recent news items, including "Announcement for early proposal planning for Cycle 11", "Restart of the Cycle 10 antenna relocations", "Announcement from ALMA director on observatory priorities during WSU implementation", "Release of Science Verification Data for W51 in Band 1", and "Release of Solar Full Polarization ALMA Test Data".
- EU ARC News:** A list of news items for the European ARC, including "Upcoming workshop 'The promises and challenges of the ALMA Wideband Sensitivity Upgrade'", "Postdoctoral Researcher for an ALMA ADP pipeline", "European ALMA school", "At the Allegro node: ALMA Data Reduction Training Day on 27 November 2023", and "Postdoctoral position(s) at the Allegro ARC node at".
- ALMA Status:** A section titled "Configuration Schedule" showing "Retired publications: 3641", "Last observed source: NGC_7252E", and "Current configuration: C-3".

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

ALMA Basics	Configuration Schedule
ALMA Science	SnooPI
ALMA Primer	DDT Proposals

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

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 page features a header with the title "UK ALMA Regional Centre" and a banner image of ALMA antennas. Below the banner is a search bar and a navigation menu with three main sections: "Local Information", "Science & Support Information", and "External Links".

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" with a play button and a "Watch on YouTube" link. Below the video is a news article titled "ALMA Creates New Images with Unprecedented Angular Resolutions" accompanied by a colorful astronomical image.

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 (GHz) from 100 to 900 GHz. The plot features several labeled lines corresponding to different molecules and transitions, such as CO, HCO, CH₃OH, and HNC. On the right, there is a table of observations with columns for Project code, ALMA source name, RA, Dec, Band, Cont. sens., Frequency support, Release date, Publications, and other parameters.

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

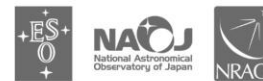
The best way to communicate with ALMA staff (including the UK ARC Node) is to use the ALMA Helpdesk at <https://help.almascience.org>.

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", a "Submit Helpdesk Ticket" button, and a "Log in" link. A large blue search bar with the placeholder text "How can we help you today?" is centered below the header. Below the search bar is a navigation menu with "Help Center", "TOO", and "Search Sci Portal" links. 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 10)

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



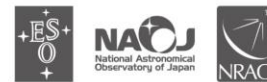
www.almascience.org

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..

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ALMA Cycle 10 Proposer’s Guide

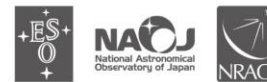


ALMA Cycle 10 Technical Handbook



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www.almascience.org

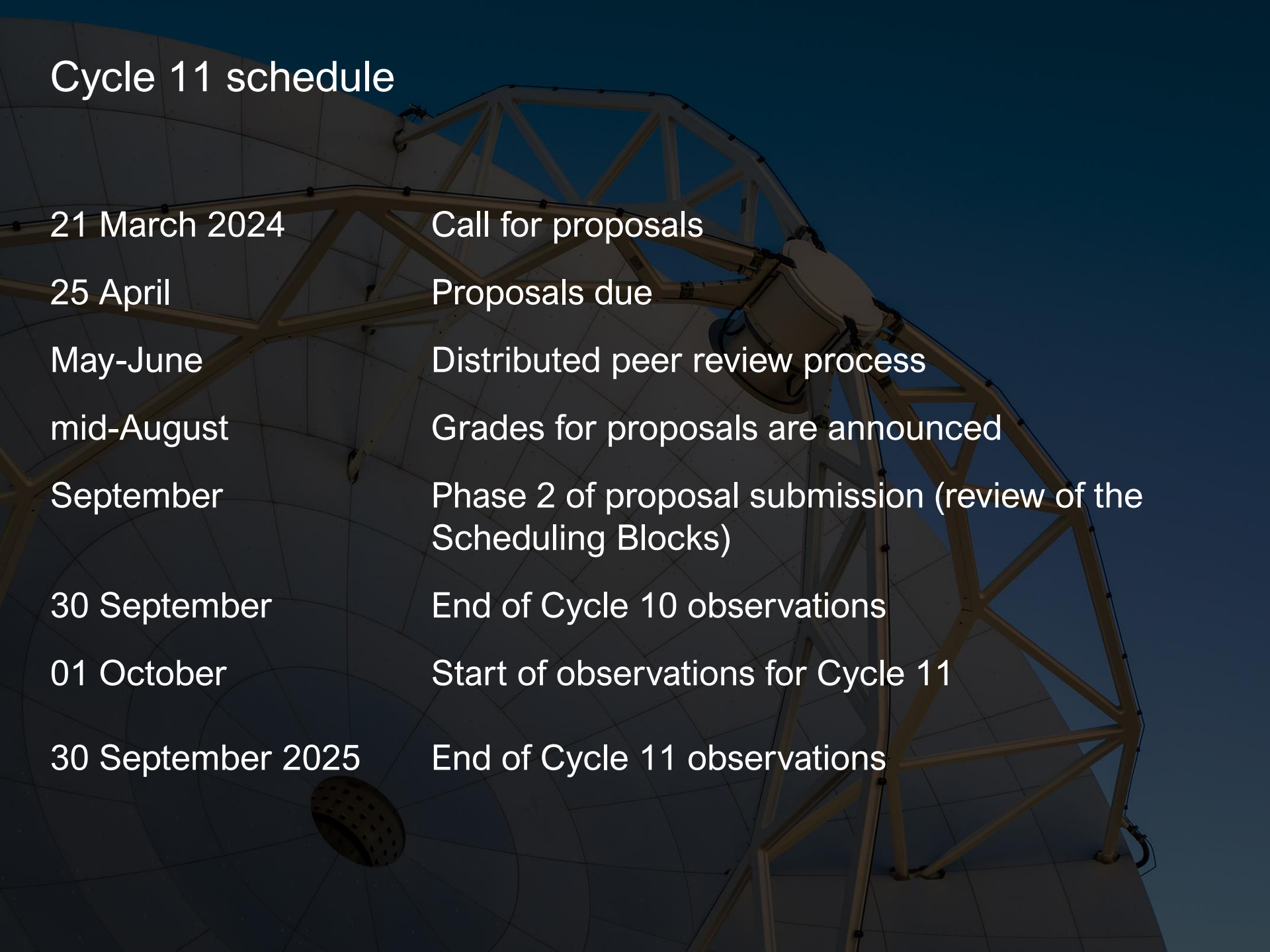
Using ALMA archival data - A Primer

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

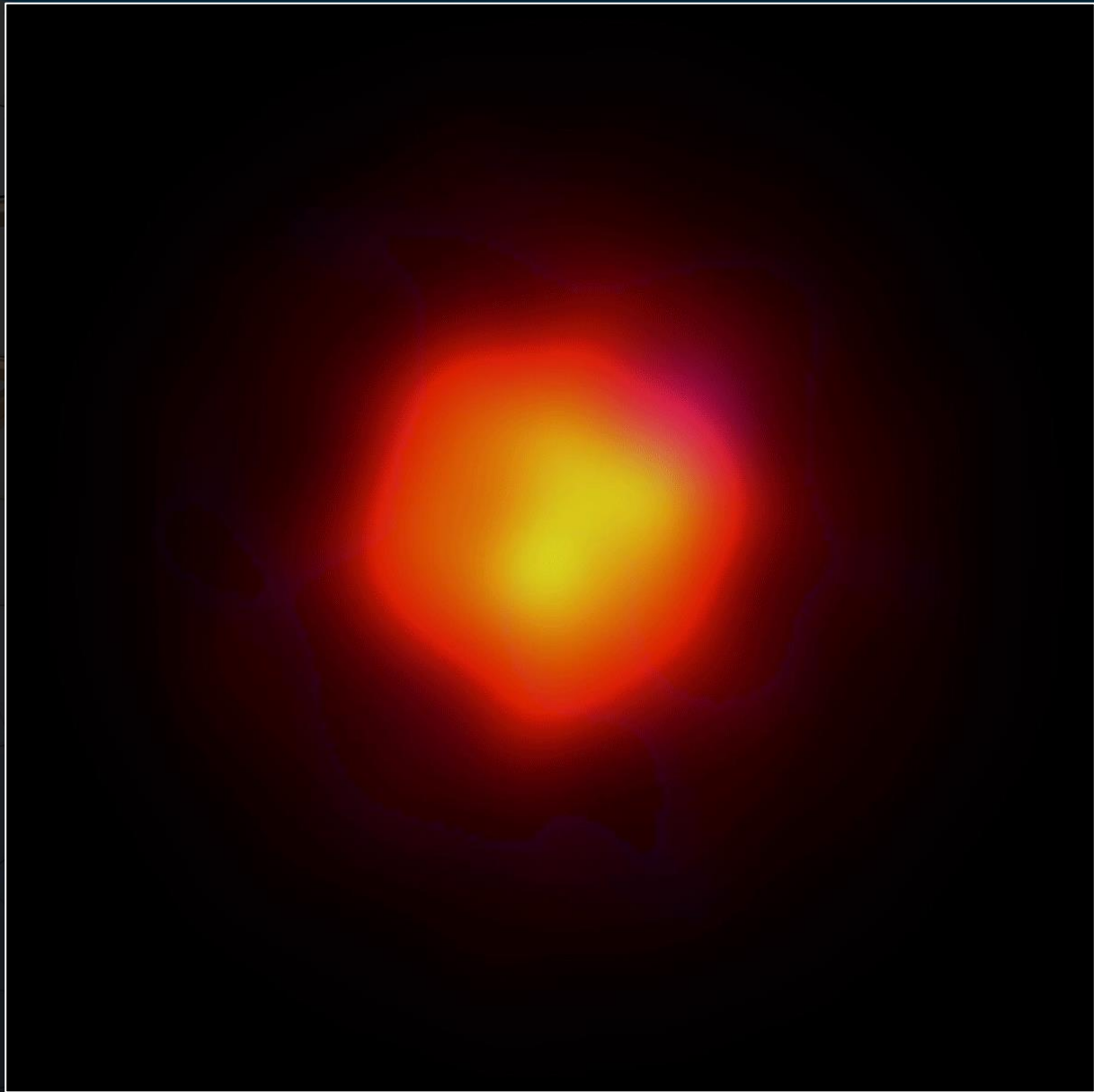


www.almascience.org

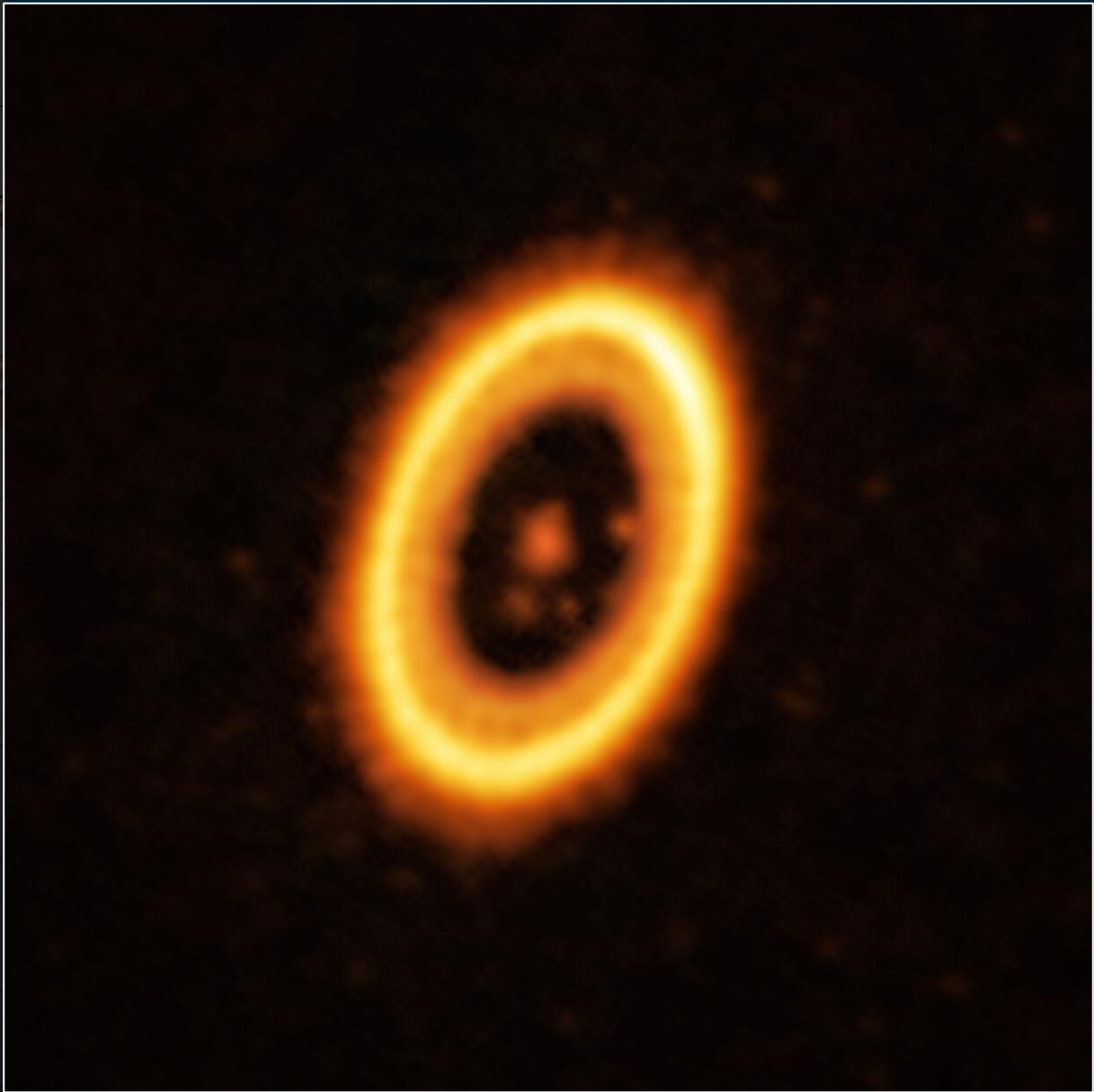
Cycle 11 schedule



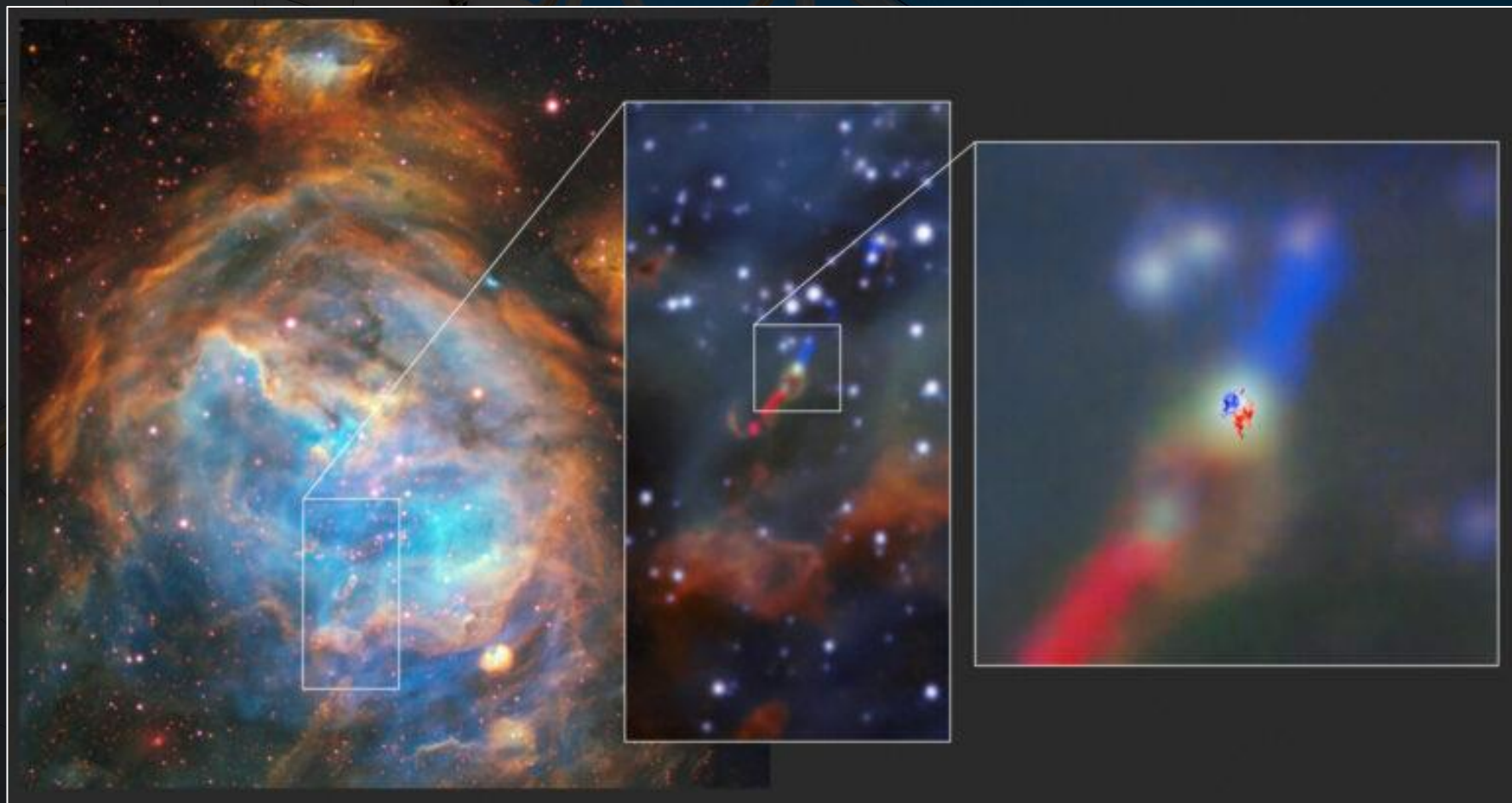
21 March 2024	Call for proposals
25 April	Proposals due
May-June	Distributed peer review process
mid-August	Grades for proposals are announced
September	Phase 2 of proposal submission (review of the Scheduling Blocks)
30 September	End of Cycle 10 observations
01 October	Start of observations for Cycle 11
30 September 2025	End of Cycle 11 observations



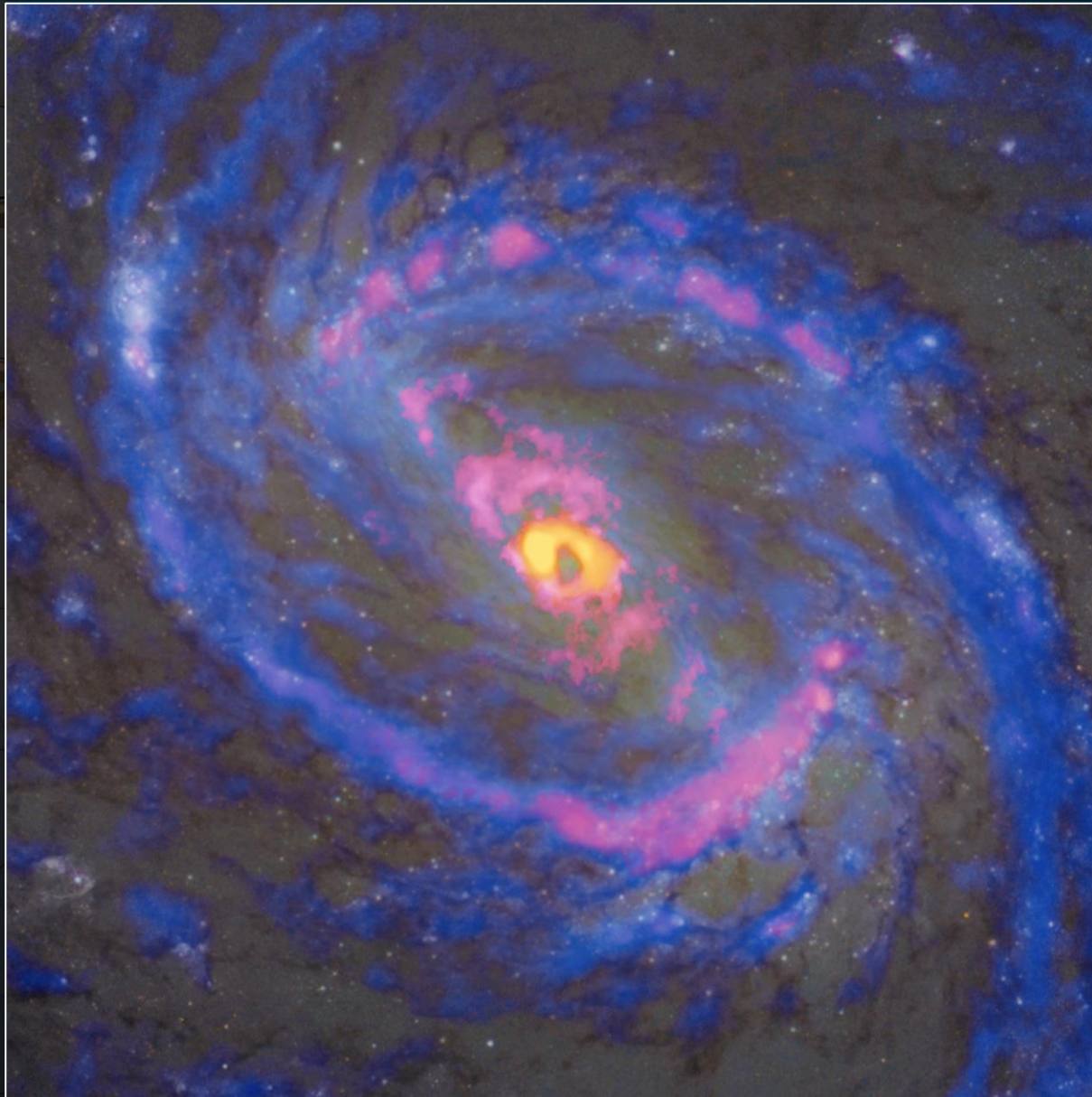
(Credit: Y. Asaki & N. Lira – ALMA (ESO/NAOJ/NRAO))



(Credit: ALMA (ESO/NAOJ/NRAO) / Balsalobre-Ruza et al.)



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



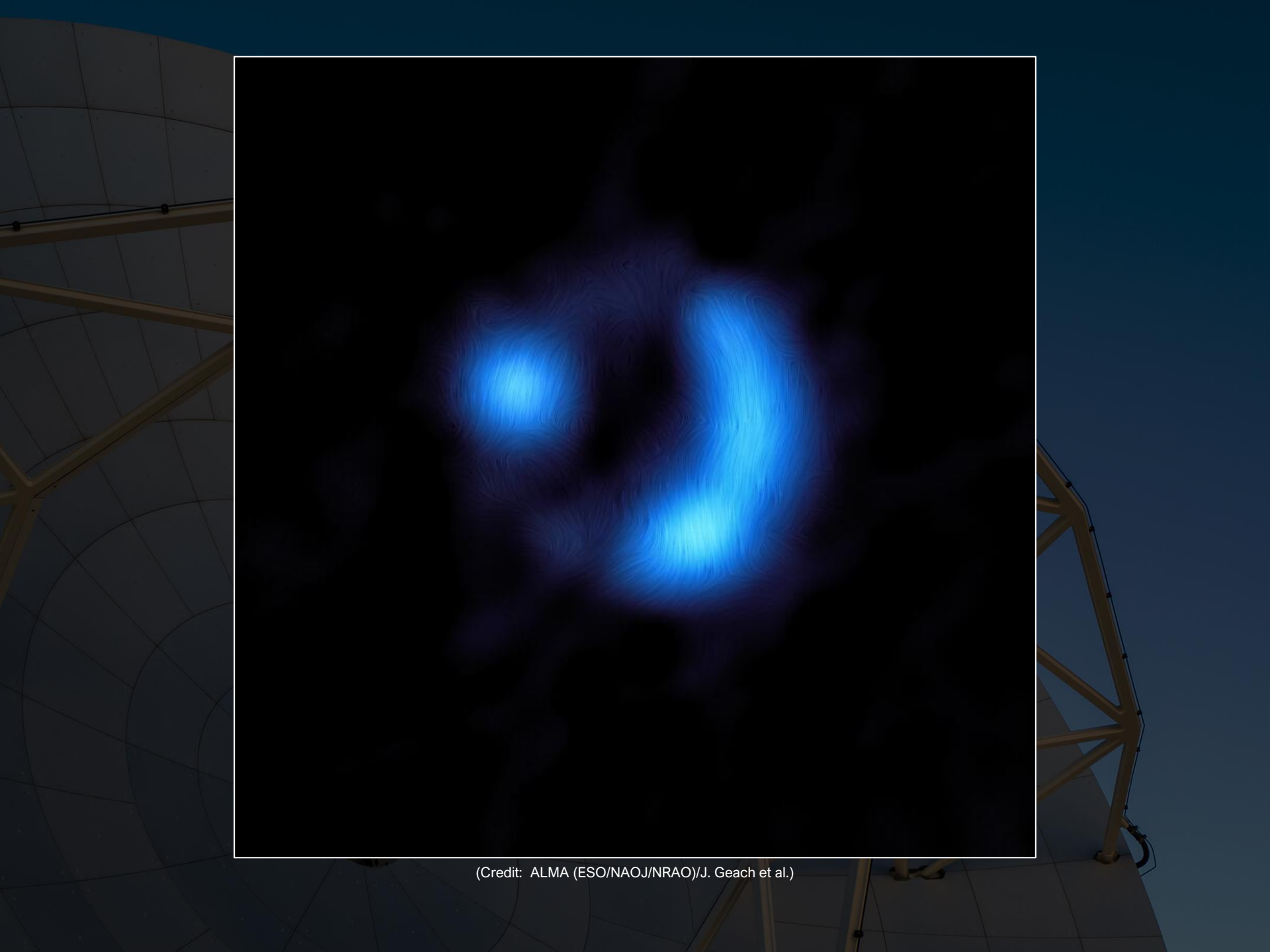
(Credit: ALMA (ESO/NAOJ/NRAO), NASA/ESA Hubble Space Telescope, T. Nakajima et al.)

2017 April 11

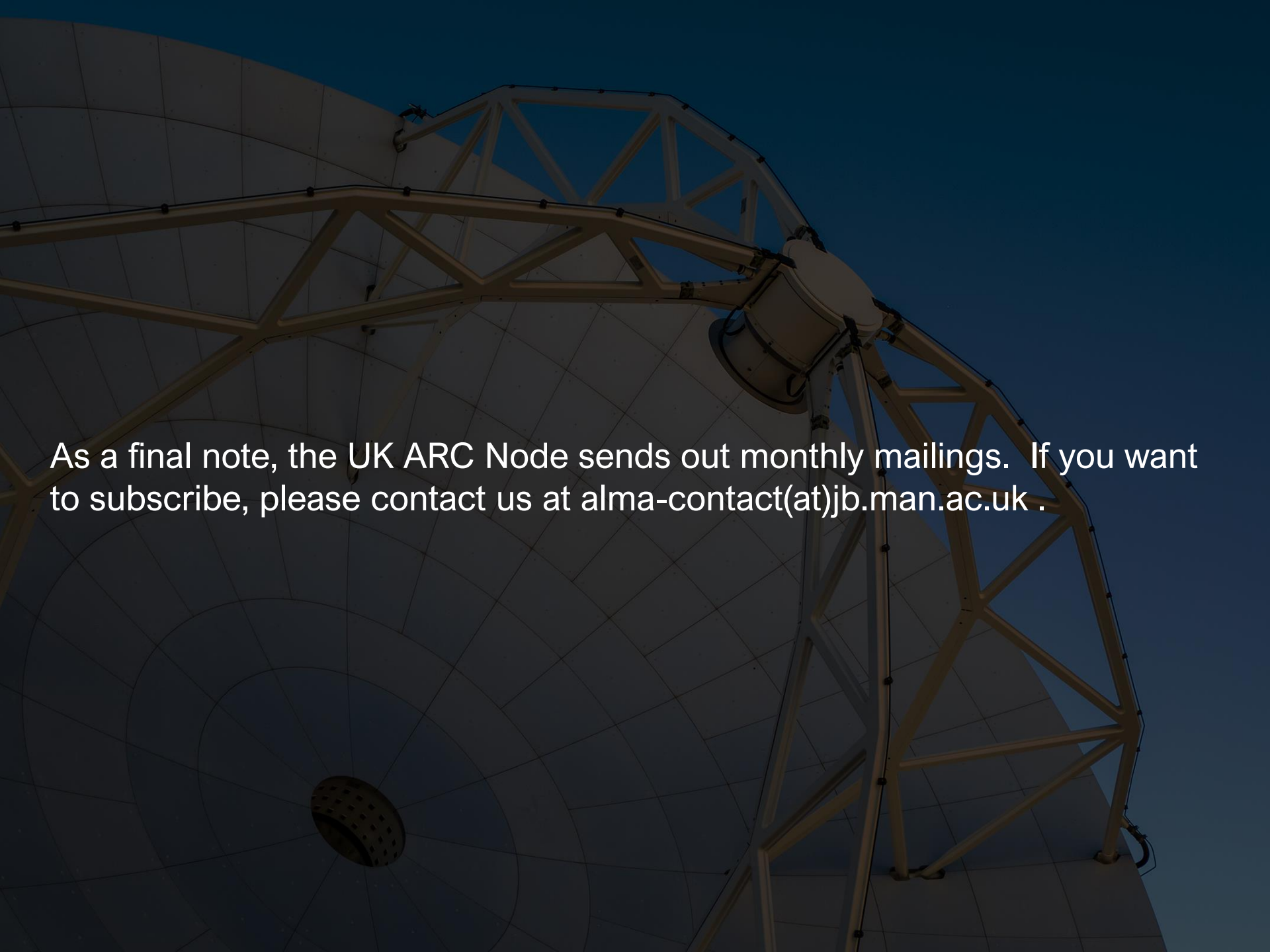
2018 April 21



(Credit: EHT Collaboration)



(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 in the lower-left quadrant of the dish. 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.