

# An Introduction to ALMA

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DA-59

DA-59









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 0.32–9.5 mm (31–950 GHz).

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.

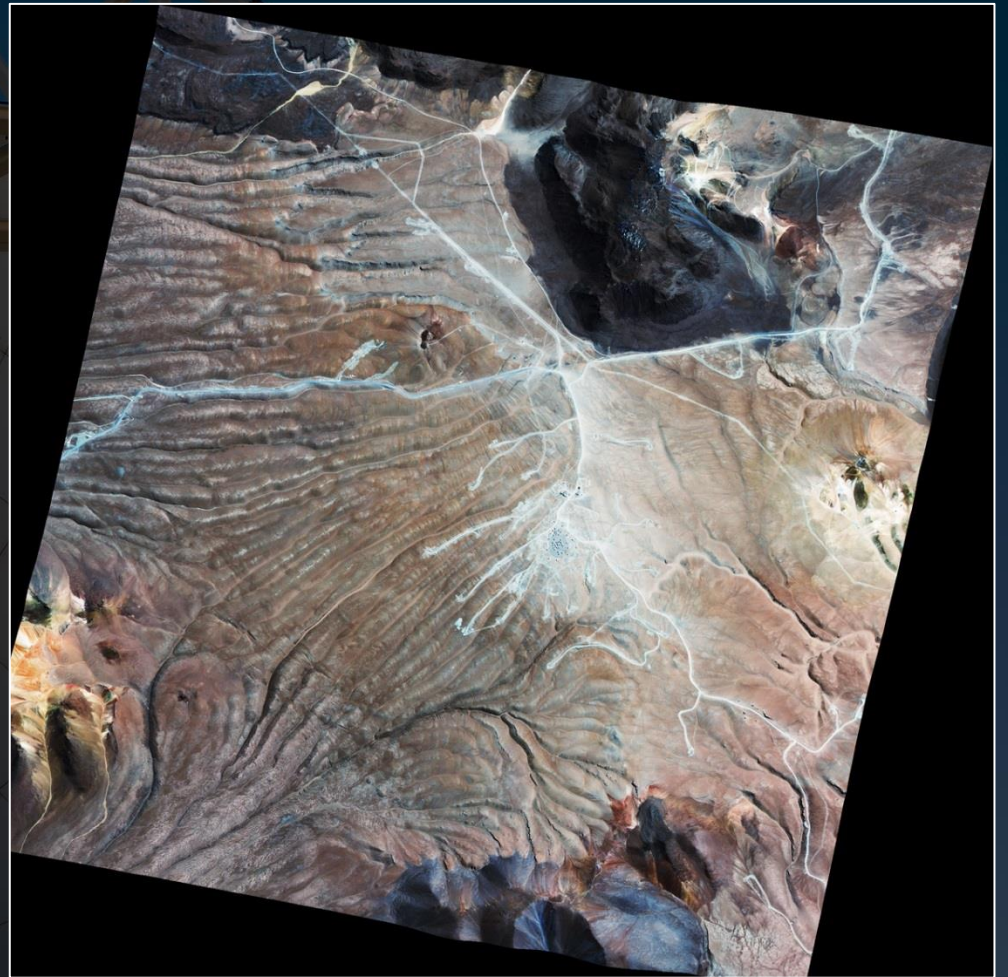
## Some of the science performed with ALMA includes:

- 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.

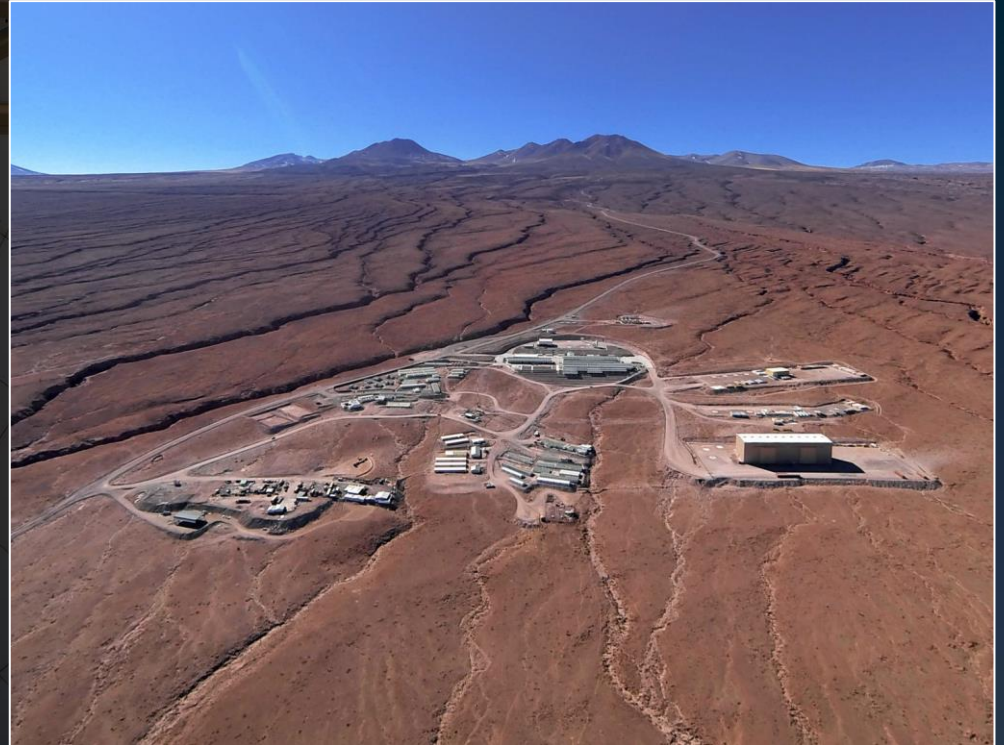
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(Credit: ESO/S. Fandango)

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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(Credit: ESO)

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



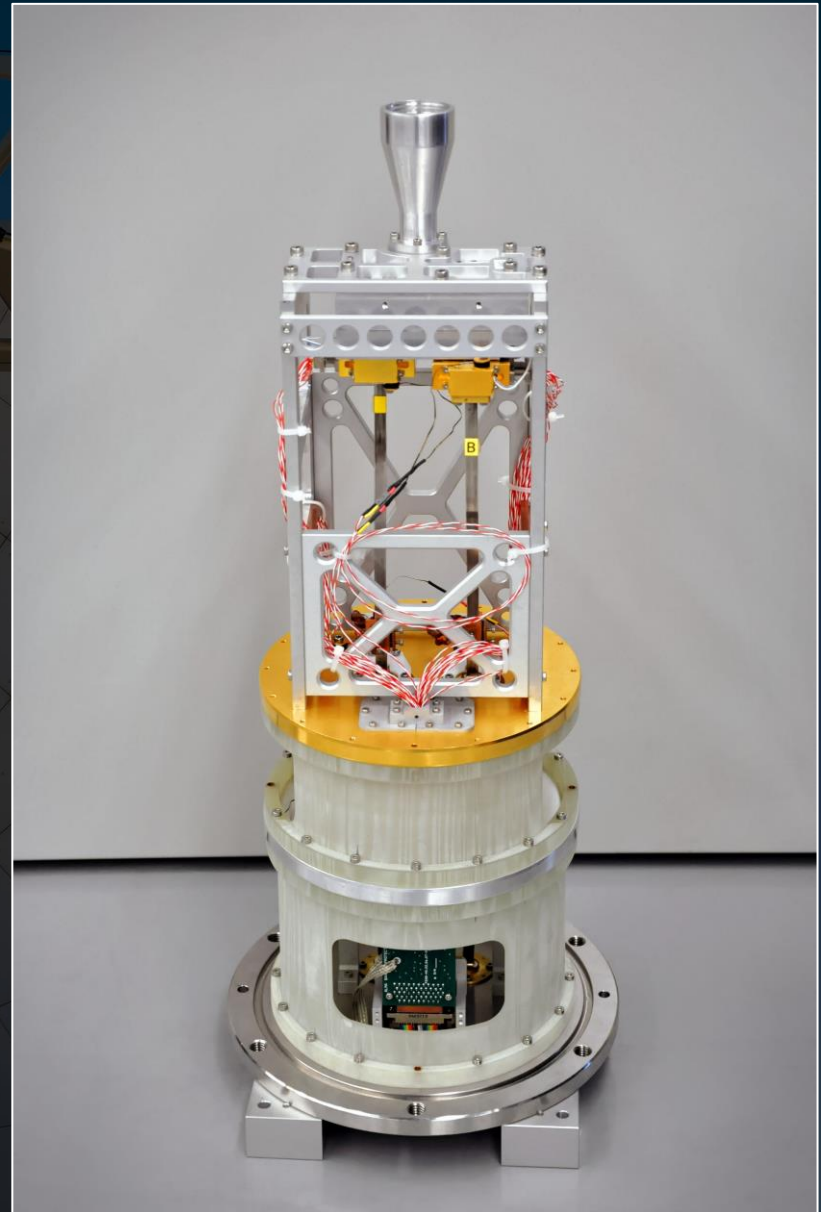
(Credit: ESO & ALMA (ESO/NAOJ/NRAO))



ALMA uses multiple sets of heterodyne receivers.

Currently, 8 bands are available.

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

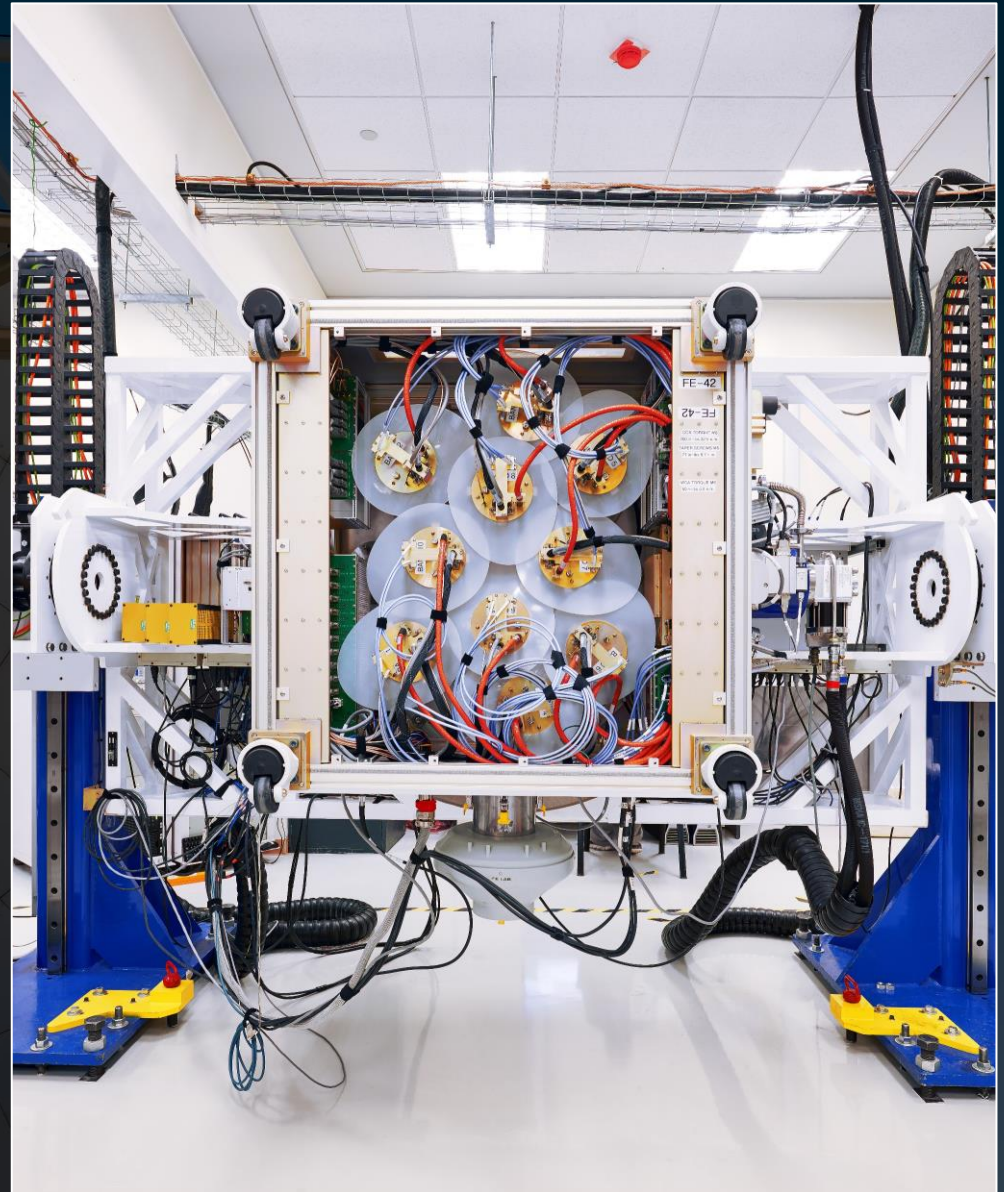


(Credit: ASIAA/NAOJ/ESO/S. Guisard ([www.eso.org/~sguisard](http://www.eso.org/~sguisard)))

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(Credit: Enrico Sacchetti/ESO)

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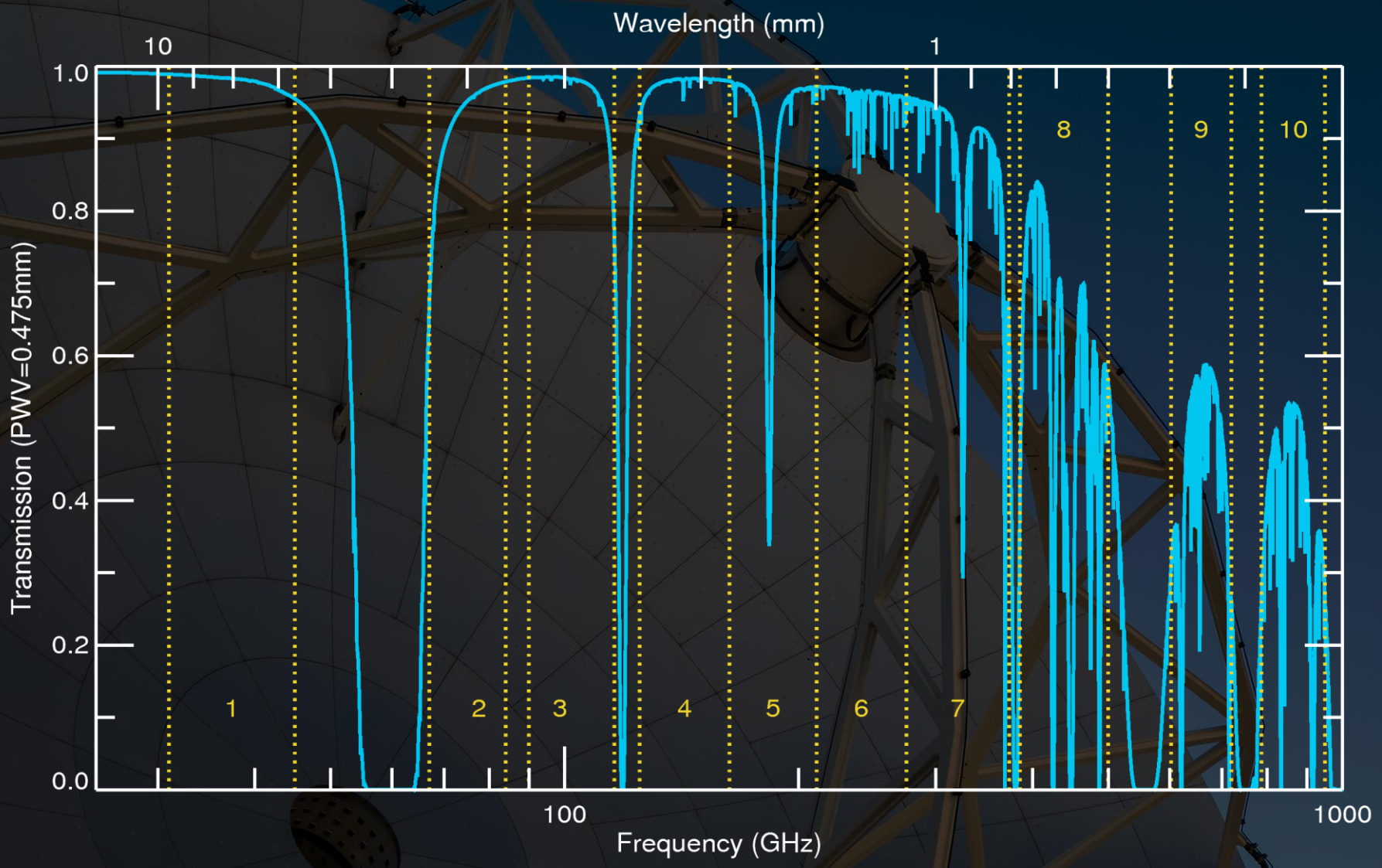
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(Credit: ESO/M. Alexander)

Band	Frequency (GHz)	Wavelength (mm)	Primary Beam (arcsec)	Angular Resolution (arcsec)	
				Compact Configuration	Extended Configuration
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)

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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.

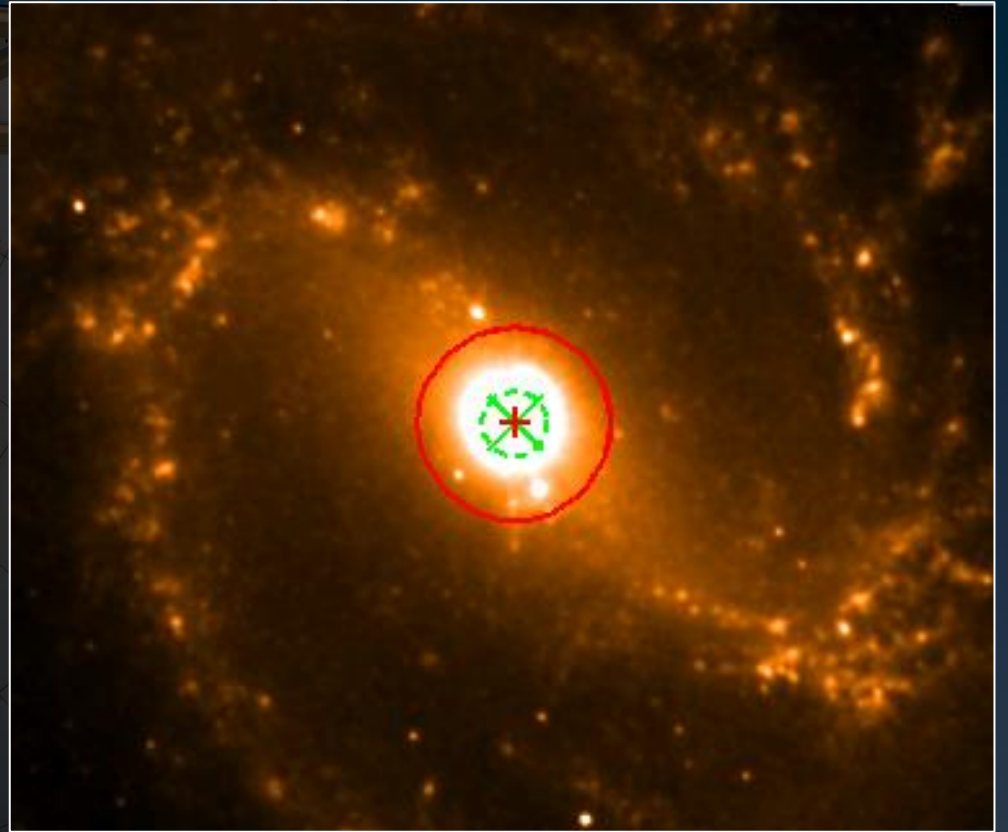


The total power antennas are used to detect large-scale line emission resolved out by both the 12m and ACA arrays. (Continuum-imaging capabilities may be added in the future.)



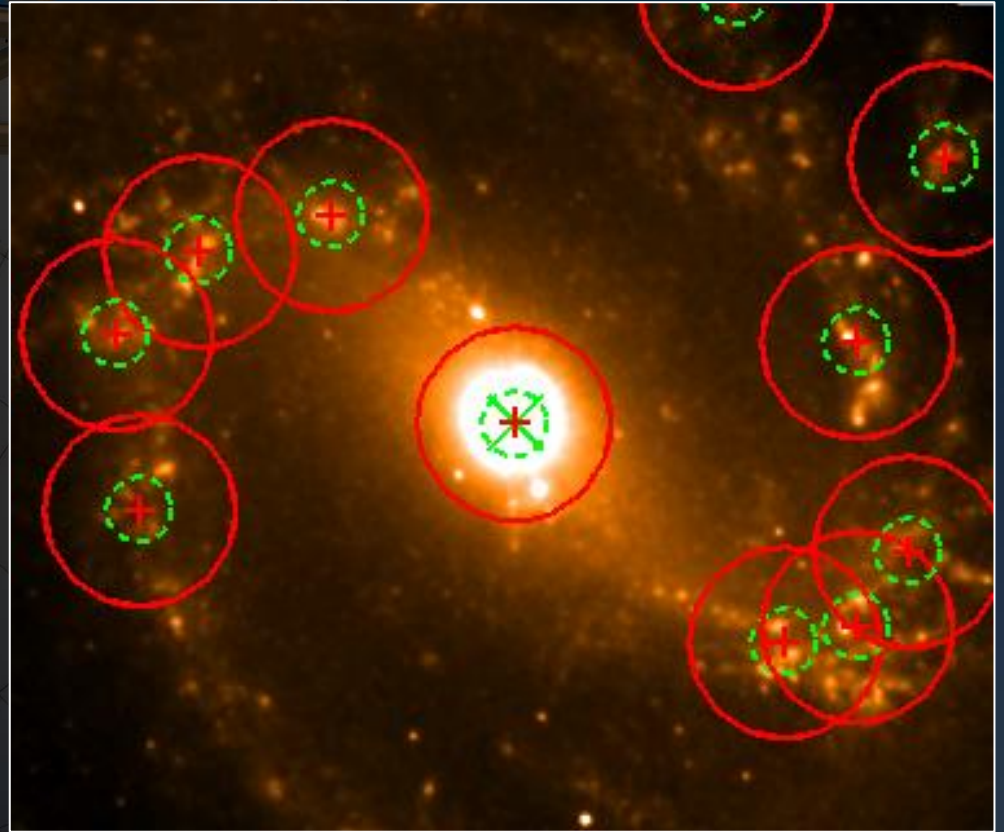
The most basic field that can be imaged by ALMA is a single pointing.

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



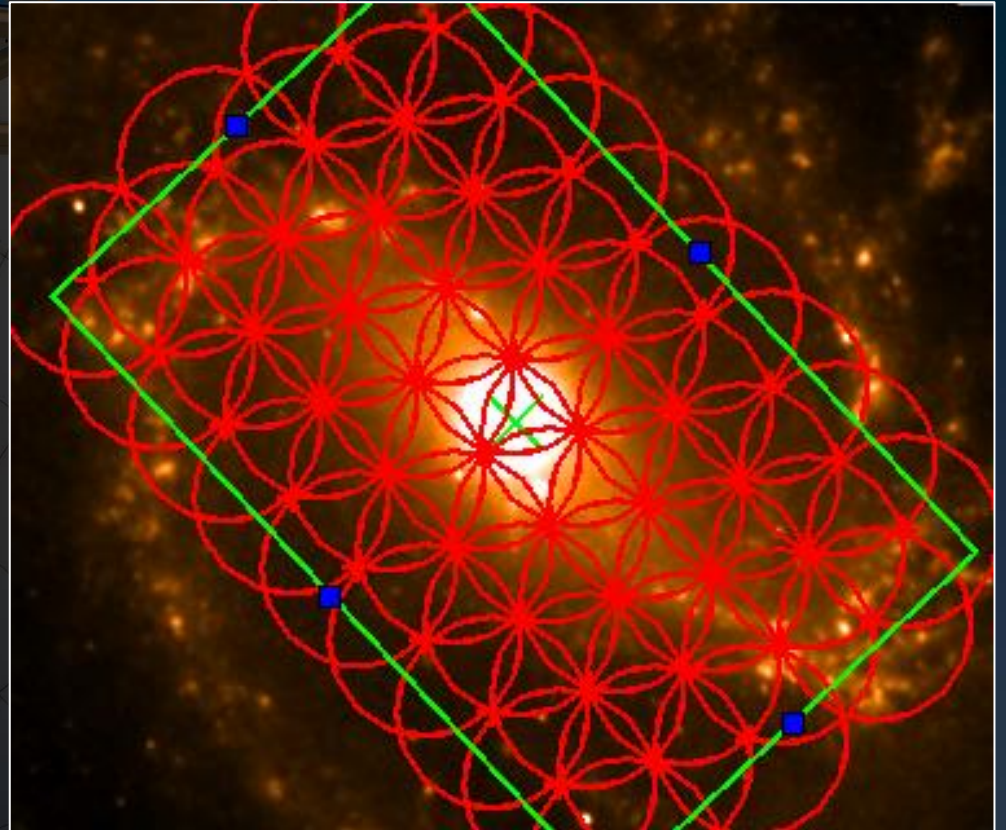
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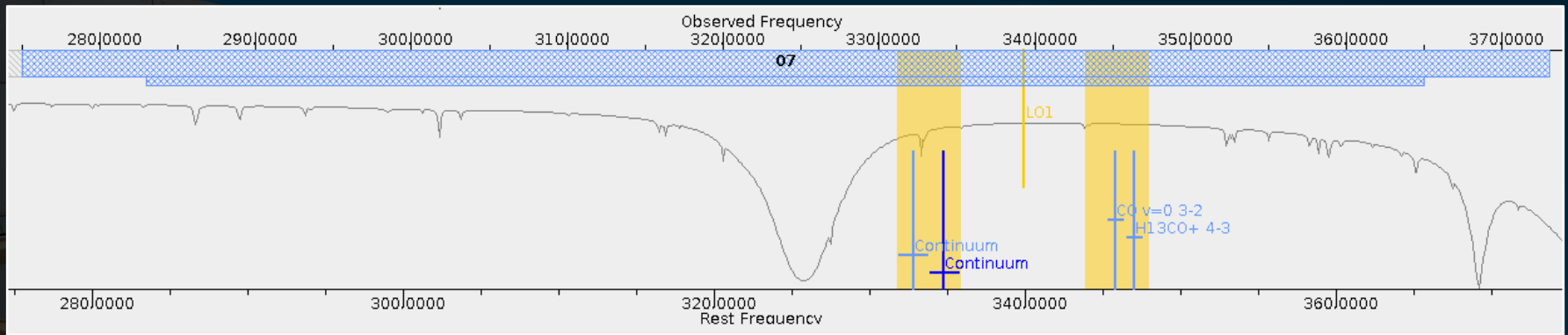
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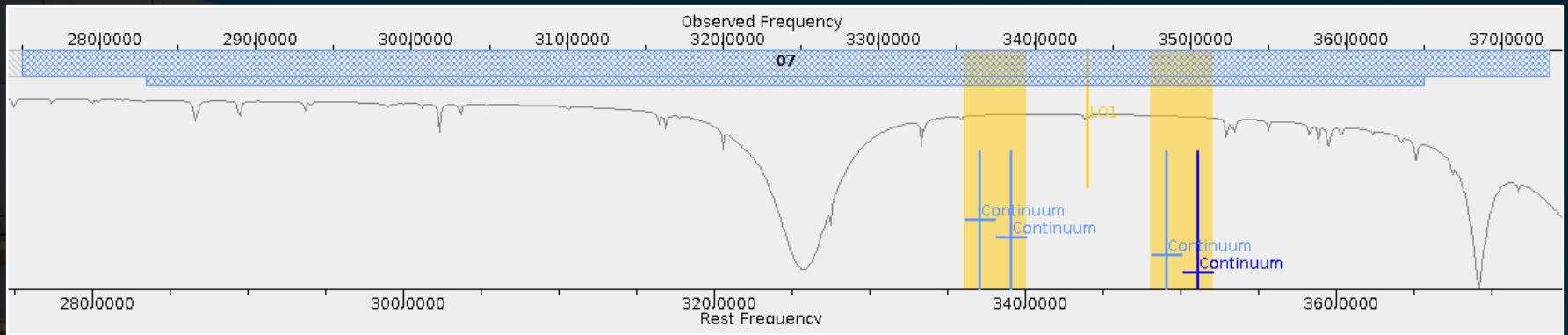


ALMA currently offers three types of spectral set-ups.

- 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).

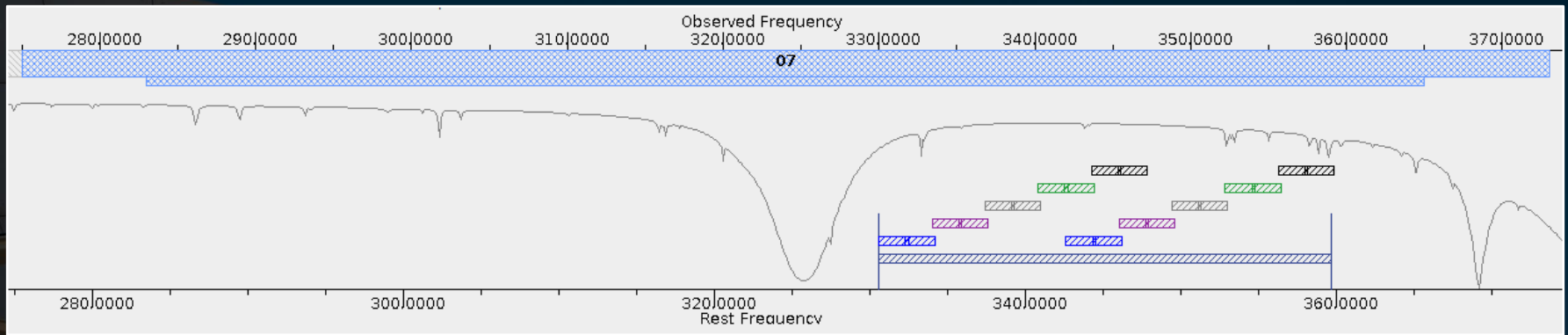


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ALMA has a series of other capabilities, including:

- Polarization observing modes
- VLBI observing modes (involving other telescopes)
- Solar observing modes
- Pulsar observing modes

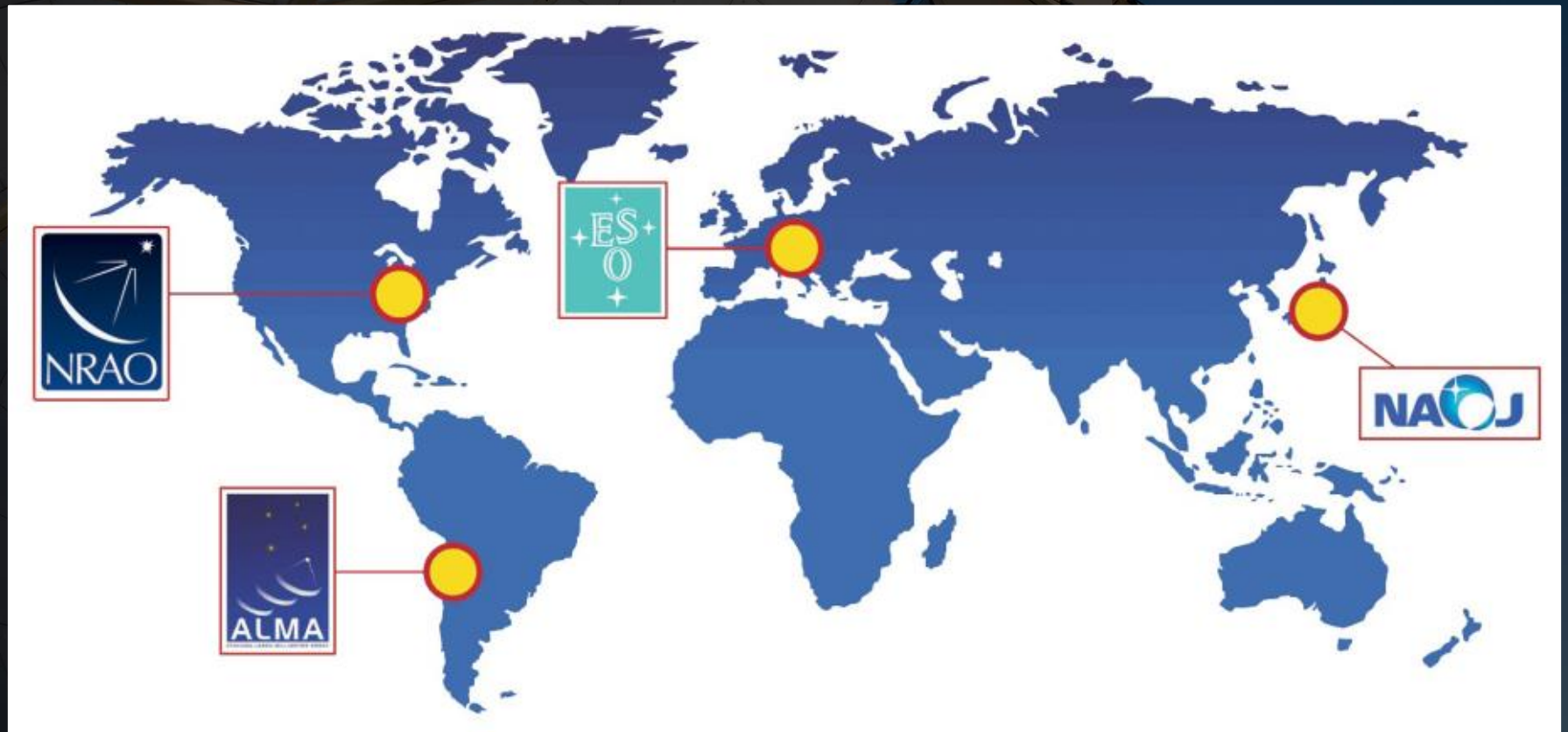
A large, white, segmented radio telescope dish is shown against a dark blue sky. The dish is supported by a complex metal truss structure. The text is overlaid on the left side of the dish.

For Cycle 9, ALMA will be offering the following new capabilities:

- Solar Total Power regional mapping scans in Bands 3, 5, 6, and 7
- VLBI continuum observations in Band 7
- VLBI spectral line observations in Band 3
- High-frequency long-baseline observations in Bands 8, 9, and 10

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

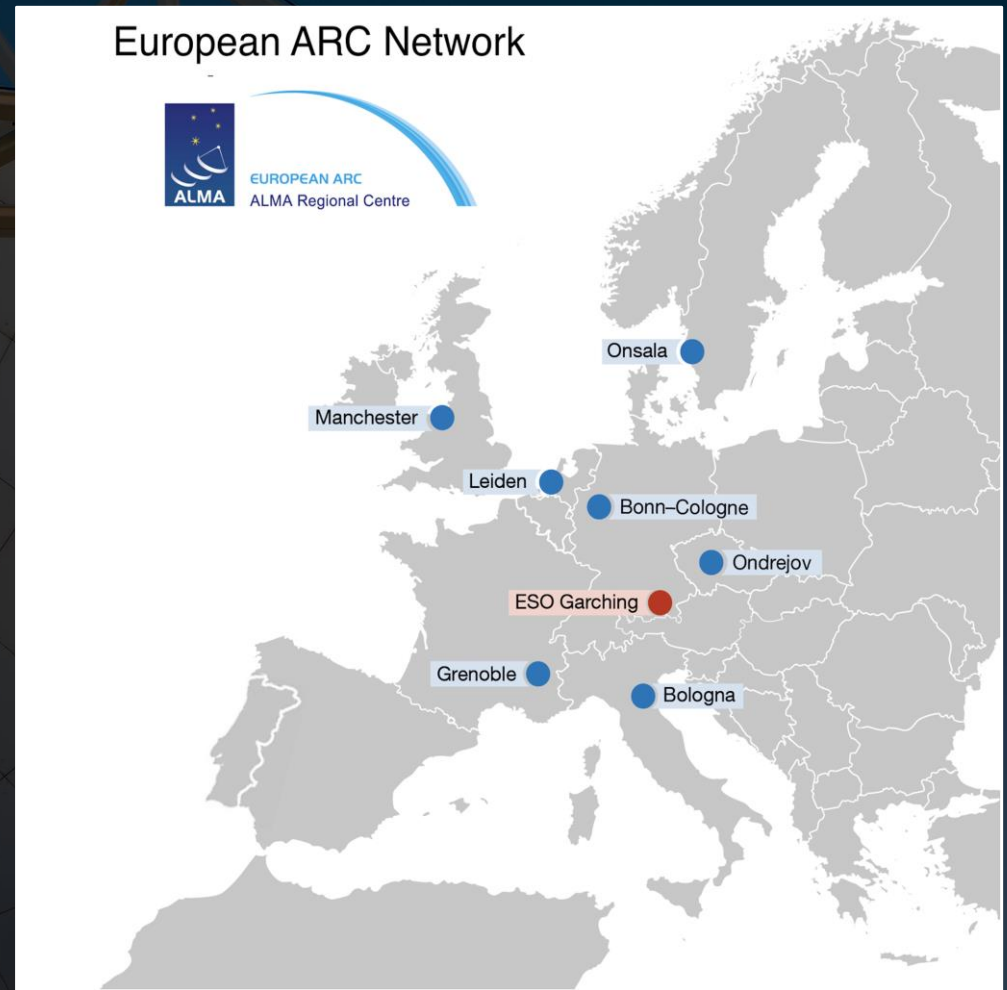
The JAO in Chile coordinates all activities.



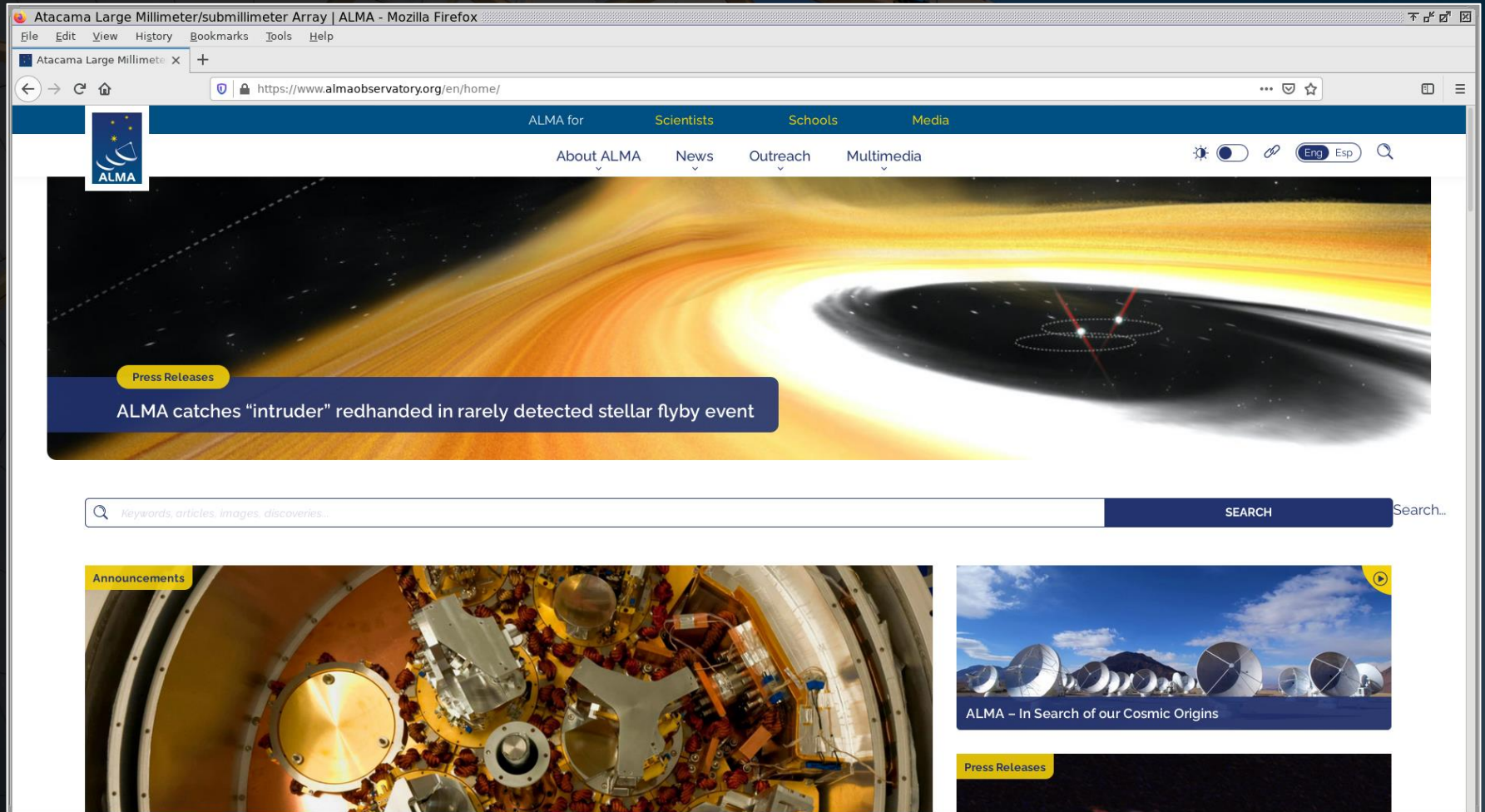
The European Southern Observatory coordinates ALMA activities in Europe.

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 <https://almaobservatory.org/> .



The screenshot shows the ALMA website homepage in a Mozilla Firefox browser window. The browser's address bar displays the URL <https://www.almaobservatory.org/en/home/>. The website features a dark blue header with the ALMA logo on the left and navigation links for "ALMA for", "Scientists", "Schools", and "Media". Below the header, there are links for "About ALMA", "News", "Outreach", and "Multimedia". A search bar is located in the top right corner, with language options for "Eng" and "Esp".

The main content area features a large, vibrant image of a protoplanetary disk (proplyd disk) with a bright central star and a dark shadow cast by the disk's edge. A blue banner at the bottom of this image contains the text "ALMA catches 'intruder' redhanded in rarely detected stellar flyby event" and a "Press Releases" button.

Below the main image is a search bar with the placeholder text "Keywords, articles, images, discoveries..." and a "SEARCH" button. The bottom section of the page includes an "Announcements" section with a photograph of the ALMA observatory's complex internal structure, and a video player titled "ALMA - In Search of our Cosmic Origins" with a "Press Releases" button below it.

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

Scientists | ALMA | ALMA - Mozilla Firefox

File Edit View History Bookmarks Tools Help

Scientists | ALMA | ALMA x +

https://www.almaobservatory.org/en/scientists/

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JAO Science Team

Visitors

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JAO Science Highlights

JAO Publications

JAO Events & Meetings

Trending Scientific Articles

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ALMA Science Portal

ALMA Regional Centers (ARC)

Publish your results in the press

ALMA Power Point Templates

All JAO Science Highlights

**ALMA Observes Interplay between Magnetic Force and Gravity in Massive Star Formation**

6 August, 2021

JAO authors: Chat Hull, Paulo Cortés

**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**

All JAO Scientists

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.

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, there is a navigation menu with links for About, Science, Proposing, Observing, Data, Processing, Tools, Documentation, and Help. Below the menu, the page is divided into several sections:

- Science Highlight:** Titled "Normal, Dust-Obscured Galaxies in the Epoch of Reionization", it features two panels of astronomical images and spectra. The top panel shows the REBELS-29 field at redshift  $z=6.68$ , and the bottom panel shows the REBELS-12 field at redshift  $z=7.35$ . Each panel includes a [CII] 158  $\mu\text{m}$  line and dust emission detection map, a zoomed-in view of the source, and a spectral plot showing the [CII] emission line.
- Observatory News:** Contains several news items:
  - "ALMA Science Archive previews" dated Feb 14, 2022.
  - "QA0+ results now available from SnooPI" dated Jan 31, 2022.
  - "ALMA Cycle 9 Pre-Announcement" dated Dec 15, 2021.
  - "ALMA Science Archive object-type search, text-based similarity search and Jupyter Notebooks" dated Dec 14, 2021.
  - "Cycle 8 2021 has started!" dated Oct 04, 2021.
- EU ARC News:** Lists several research associate positions:
  - "ALMA Regional Centre Astronomer - ESO Garching" (closed) dated Dec 09, 2021.
  - "Research associate – ARC node researcher/developer" (closed) dated Dec 06, 2021.
  - "Research Associate (UK ARC Node Scientist) position" (closed) dated Nov 15, 2021.
  - "Research Associate (UK ARC Node Scientist) position" (closed) dated Jul 05, 2021.
- ALMA Status:** Shows the "Configuration Schedule" and provides statistics: "Referred publications: 2689", "Last-observed source: ESO097-013", and "Current configuration: C-3".

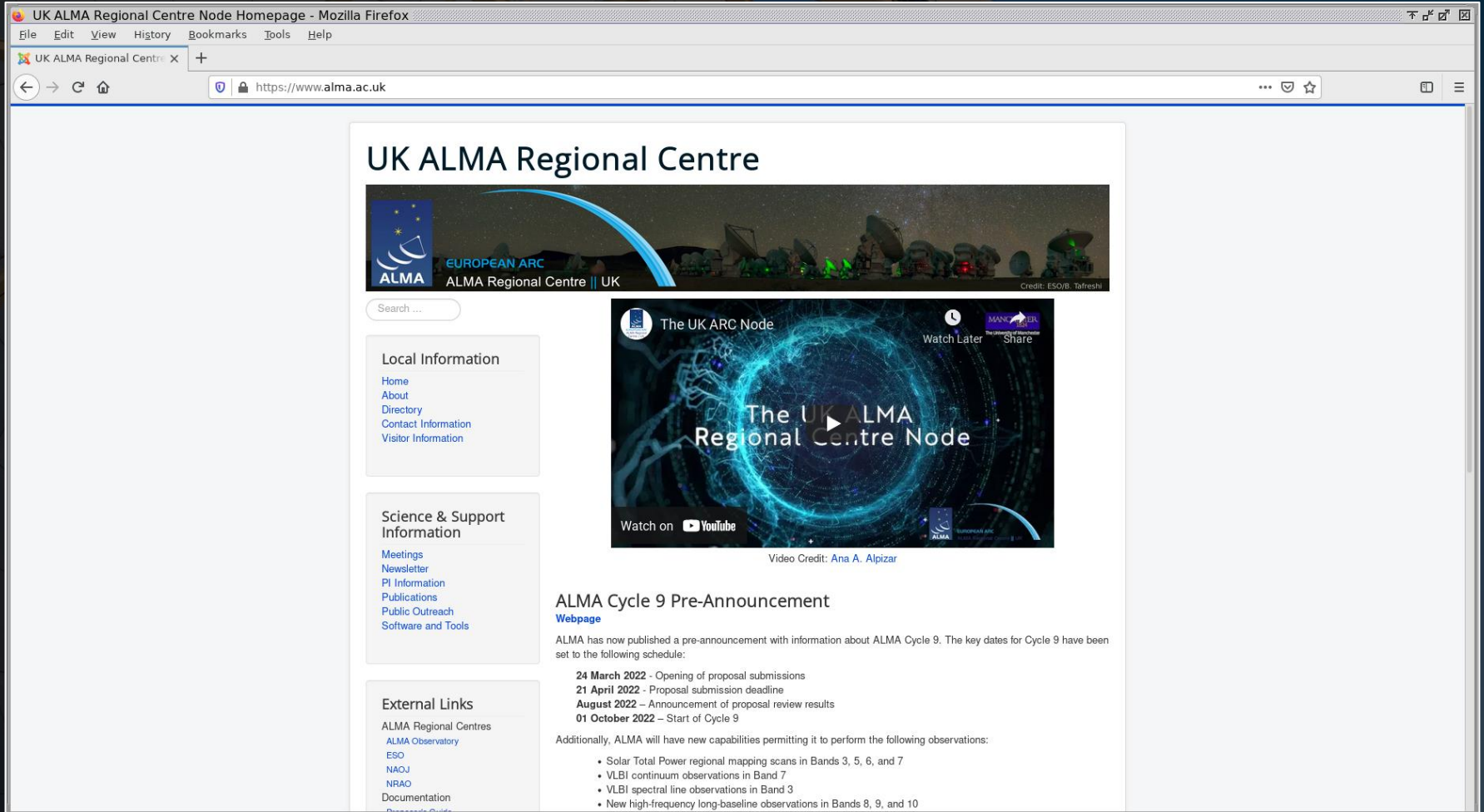
At the bottom of the page, there is a "Quick Links" section with a grid of links: ALMA Basics, ALMA Archive, ALMA Science, SnooPI, and ALMA Primer, Configuration Schedule.

The URL in the browser's address bar is <https://almascience.eso.org/>.

[CII] 158  $\mu\text{m}$  line and dust emission detections for (a) the REBELS-29 field at  $z=6.68$  and (b) the REBELS-12 field at  $z=7.35$ . Background images are HST F140W and VIDEO J-band, respectively.

As part of the ongoing ALMA large program REBELS (Reionization-Era Bright Emission Line Survey), 40 UV-luminous primary targets were observed at  $z > 6.5$ . Among these targets are REBELS-12 and REBELS-29. In their recent paper, Fudamoto and colleagues report two additional emission line neighbours found after inspecting the ALMA data cube of these two sources. The images on the left show [CII] 158  $\mu\text{m}$  line and dust emission detections for (a) the REBELS-29 field at  $z=6.68$  and (b) the REBELS-12 field at  $z=7.35$ . Background images are HST F140W and VIDEO J-band, respectively. White horizontal bars correspond to 10 proper kpc. Solid red and light blue contours show  $2\sigma$  to  $5\sigma$  levels (and  $-5\sigma$  to  $-2\sigma$  for dashed contours) for the continuum and [CII] moment-0 maps, respectively. The continuum...

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 the homepage of the UK ALMA Regional Centre. The browser window title is "UK ALMA Regional Centre Node Homepage - Mozilla Firefox". The address bar shows the URL "https://www.alma.ac.uk".

## UK ALMA Regional Centre

Search ...

### Local Information

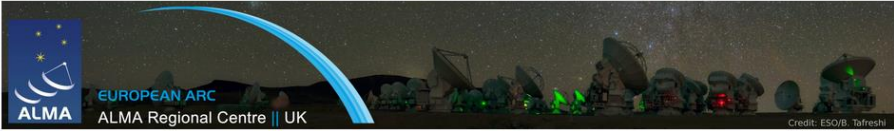
- [Home](#)
- [About](#)
- [Directory](#)
- [Contact Information](#)
- [Visitor Information](#)

### Science & Support Information


- [Meetings](#)
- [Newsletter](#)
- [PI Information](#)
- [Publications](#)
- [Public Outreach](#)
- [Software and Tools](#)


### External Links

- [ALMA Regional Centres](#)
- [ALMA Observatory](#)
- [ESO](#)
- [NAOJ](#)
- [NRAO](#)
- [Documentation](#)
- [Research Guide](#)



Credit: ESO/B. Tafreshi



Watch on  YouTube

Video Credit: Ana A. Alpizar

### ALMA Cycle 9 Pre-Announcement

[Webpage](#)

ALMA has now published a pre-announcement with information about ALMA Cycle 9. The key dates for Cycle 9 have been set to the following schedule:

- 24 March 2022** - Opening of proposal submissions
- 21 April 2022** - Proposal submission deadline
- August 2022** - Announcement of proposal review results
- 01 October 2022** - Start of Cycle 9

Additionally, ALMA will have new capabilities permitting it to perform the following observations:

- Solar Total Power regional mapping scans in Bands 3, 5, 6, and 7
- VLBI continuum observations in Band 7
- VLBI spectral line observations in Band 3
- New high-frequency long-baseline observations in Bands 8, 9, and 10



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

ALMA Science Archive - Mozilla Firefox

ALMA Science Archive x +

https://almascience.eso.org/aq/?result\_view=observation

17 45 40.041 -29 00 28.12  
FoV: 176.56°

The interface displays a spectral plot on the right with 10 labeled peaks. The x-axis represents frequency in GHz, ranging from 100 to 900. The y-axis represents flux density. The peaks are labeled with their corresponding molecules and lines:

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

Observations (53522) | Projects (3756) | Publications (2661)

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	Scientific category	Science keyword	Int. Time	Gal. lon.
		h:m:s	d:m:s		mJy/beam				arcsec	km/s			arcsec	arcsec			s	
2018.1.01205.L	IRAS_15398-3359	15:43:02.242	-34:09:06.805	6	0.0532	216.08..234.73GHz	0012-01-20	2	1.204	0.183	12m		22.473	25.833	ISM and star formation	Low-mass star formatio...	756.000	338.90°
2011.0.00191.S	Fomalhaut b	22:57:38.685	-29:37:12.616	7	0.1181	343.08..358.84GHz	2012-12-06	2	1.021	0.816	12m		14.433	16.592	Disks and planet format...	Debris disks, Exoplanets	8709.120	20.493°
2011.0.00131.S	R Scl	01:26:58.079	-32:32:36.424	7	0.9115	330.25..346.11GHz	2012-12-06	5	1.241	0.846	12m	mosaic	14.979	62.007	Stars and stellar evoluti...	Asymptotic Giant Branc...	661.617	250.18°
2011.0.00101.S	GRB021004	00:26:54.680	+18:55:41.600	7	0.1136	337.01..353.00GHz	2012-12-06	2	1.322	26.541	12m		14.682	16.878	Active galaxies	Starburst galaxies, Ga...	3749.760	114.91°
2011.0.00397.S	J035448.24-330827.2	03:54:48.240	-33:08:27.200	7	0.4848	337.03..353.01GHz	2012-12-20	3	1.372	26.541	12m		10.183	16.877	Active galaxies	Active Galactic Nuclei (...)	90.720	233.09°
2011.0.00397.S	J041754.10-281655.9	04:17:54.100	-28:16:55.900	7	0.4848	337.02..353.01GHz	2012-12-20	3	1.400	26.541	12m		10.521	16.877	Active galaxies	Active Galactic Nuclei (...)	90.720	226.95°
2011.0.00397.S	J063027.81-212058.6	06:30:27.810	-21:20:58.600	7	0.5346	337.01..352.99GHz	2012-12-20	3	1.279	26.541	12m		8.285	16.878	Active galaxies	Active Galactic Nuclei (...)	90.720	230.02°
2011.0.00397.S	J061200.23-062209.6	06:12:00.230	-06:22:09.600	7	0.5346	337.00..352.99GHz	2012-12-20	3	1.303	26.541	12m		8.827	16.878	Active galaxies	Active Galactic Nuclei (...)	90.720	214.16°
2011.0.00397.S	J054930.06-373940.1	05:49:30.060	-37:39:40.100	7	0.4848	337.02..353.00GHz	2012-12-20	3	1.388	26.541	12m		13.892	16.878	Active galaxies	Active Galactic Nuclei (...)	90.720	243.32°
2011.0.00397.S	J070257.20-280842.3	07:02:57.200	-28:08:42.300	7	0.5346	337.01..352.99GHz	2012-12-20	3	1.272	26.541	12m		8.044	16.878	Active galaxies	Active Galactic Nuclei (...)	90.720	239.48°

Questions related to ALMA (including about CASA) can be sent via the ALMA Helpdesk at <https://help.almascience.org/>.

The screenshot shows a Mozilla Firefox browser window displaying the ALMA Science Helpdesk website. The browser's address bar shows the URL <https://help.almascience.org/>. The website header includes the ALMA logo and the text "Atacama Large Millimeter/submillimeter Array" and "Observer Support". Below the header, there is a navigation bar with "ALMA Science" on the left, 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 on the page. Below the search bar, there are three navigation links: "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). At the bottom of the page, a white box contains the text "Welcome to the new ALMA Helpdesk User Interface!".

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 8)

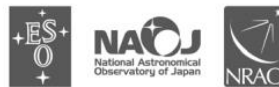


[www.almascience.org](http://www.almascience.org)

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## ALMA Cycle 8 Proposer’s Guide



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Doc 8.3, ver. 1.0 | 13 Jan, 2020

## ALMA Cycle 8 Technical Handbook

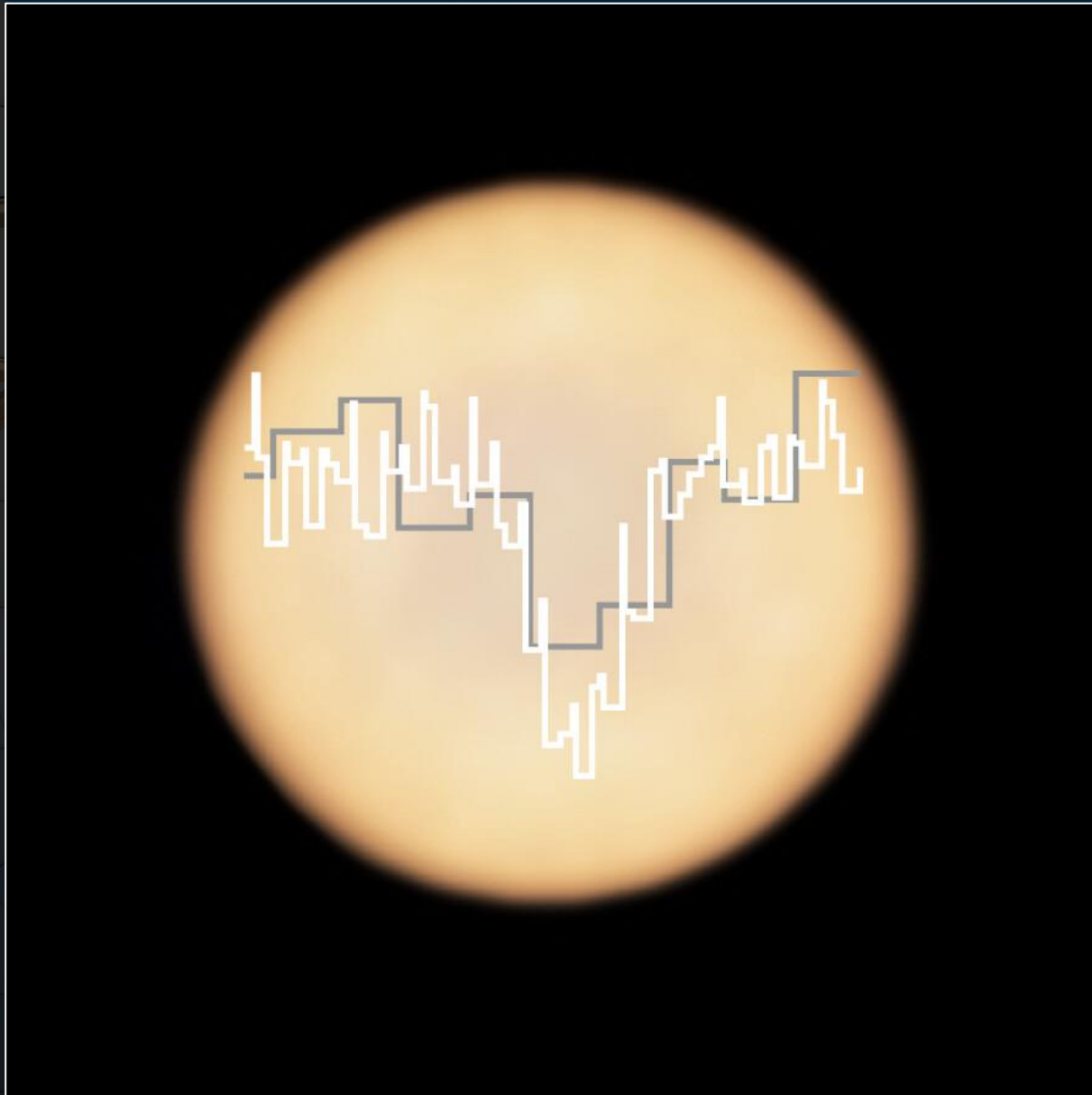


[www.almascience.org](http://www.almascience.org)

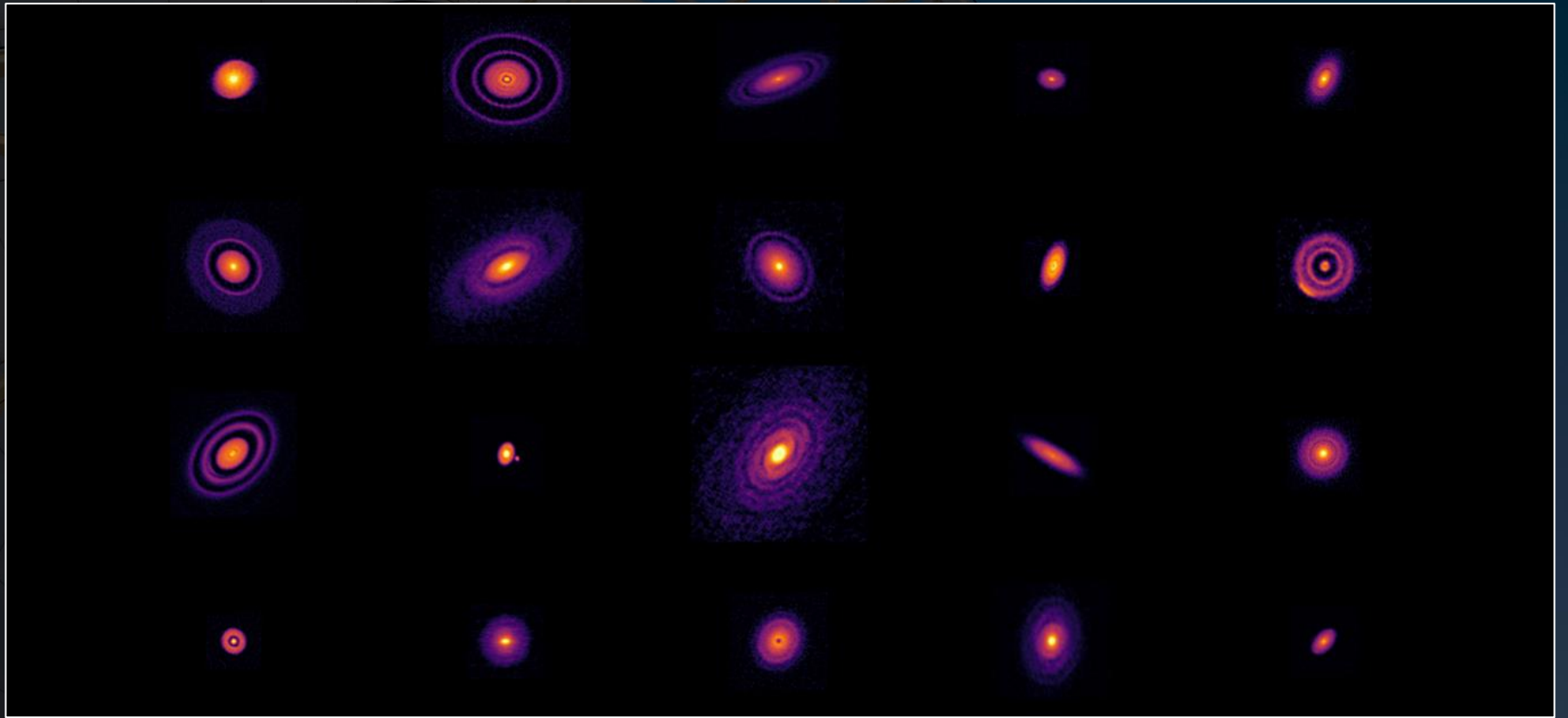
ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), MOST and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ.

## Cycle 9 schedule

- |             |   |
|-------------|---|
| 15 Dec 2021 | Cycle 9 pre-announcement  |
| 24 Mar 2022 | Call for proposals (including release of the updated Observing Tool and opening of the archive for proposal submission) |
| 21 Apr 2022 | Proposal submission deadline  |
| Aug 2022    | Announcement of results of the proposal review process  |
| 1 Oct 2022  | Beginning of Cycle 9  |
| 30 Sep 2023 | End of Cycle 9  |

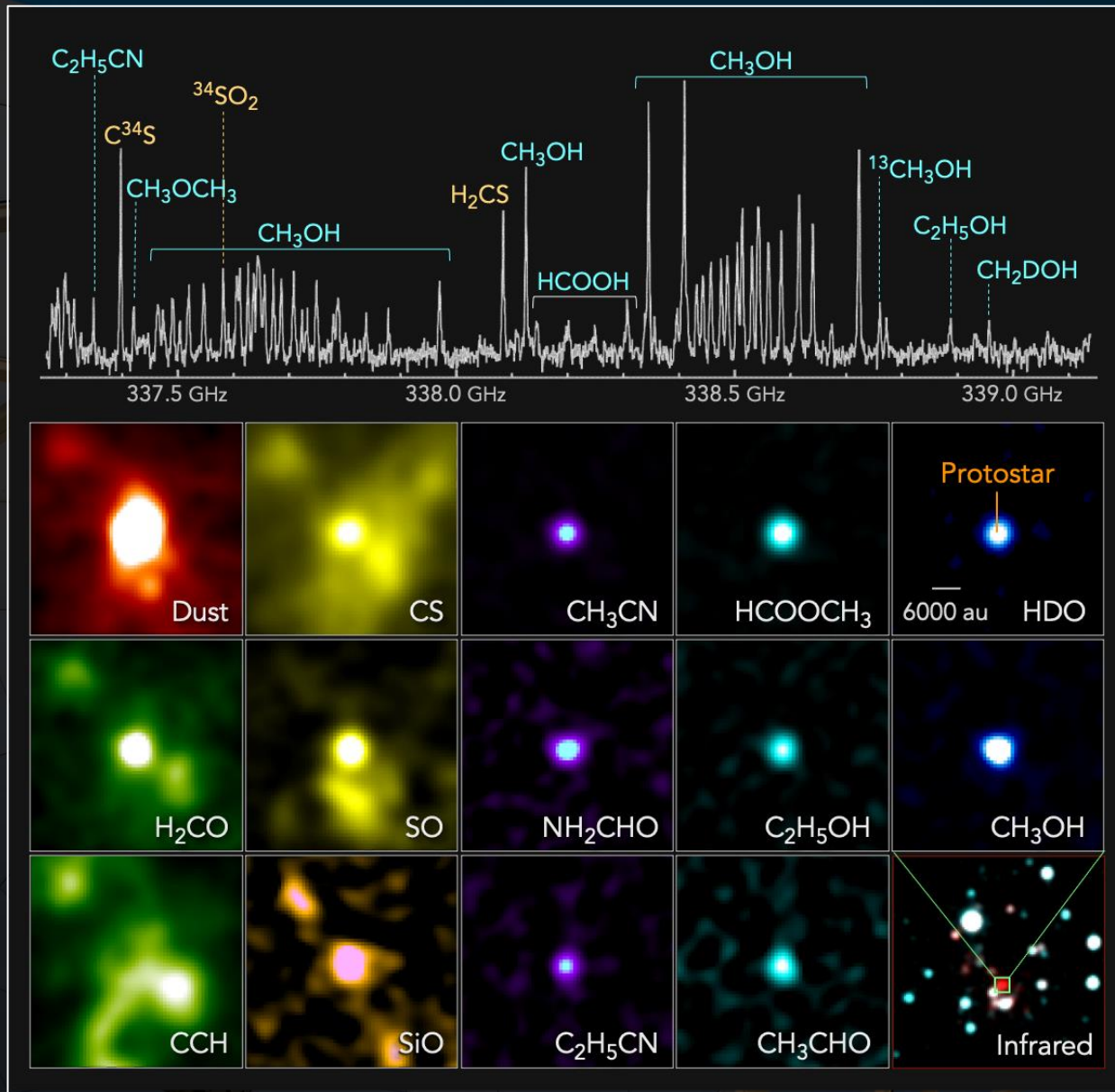


(Credit: ALMA (ESO/NAOJ/NRAO), Greaves et al. & JCMT (East Asian Observatory))

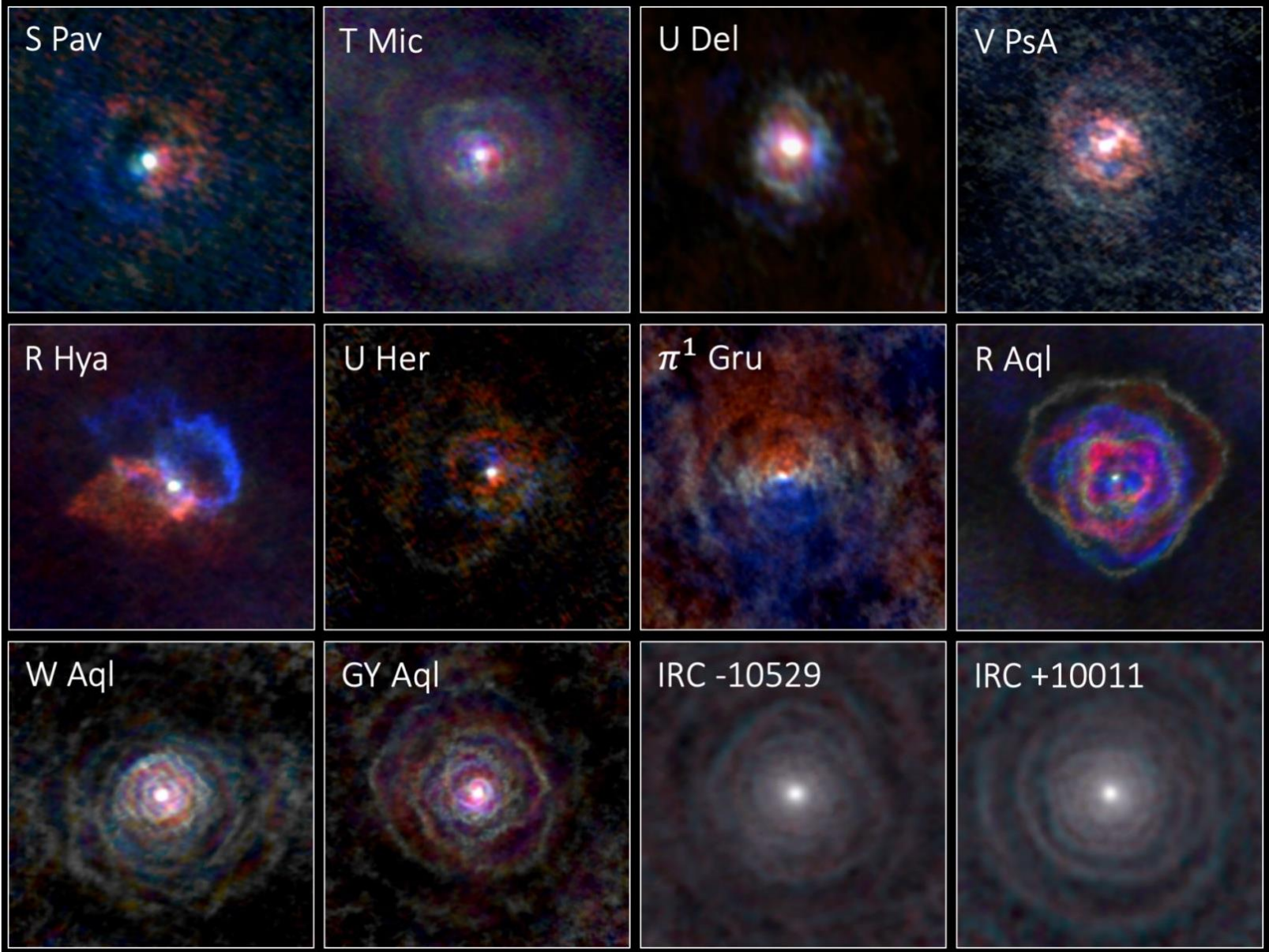


(Credit: ALMA (ESO/NAOJ/NRAO), S. Andrews et al.; N. Lira)

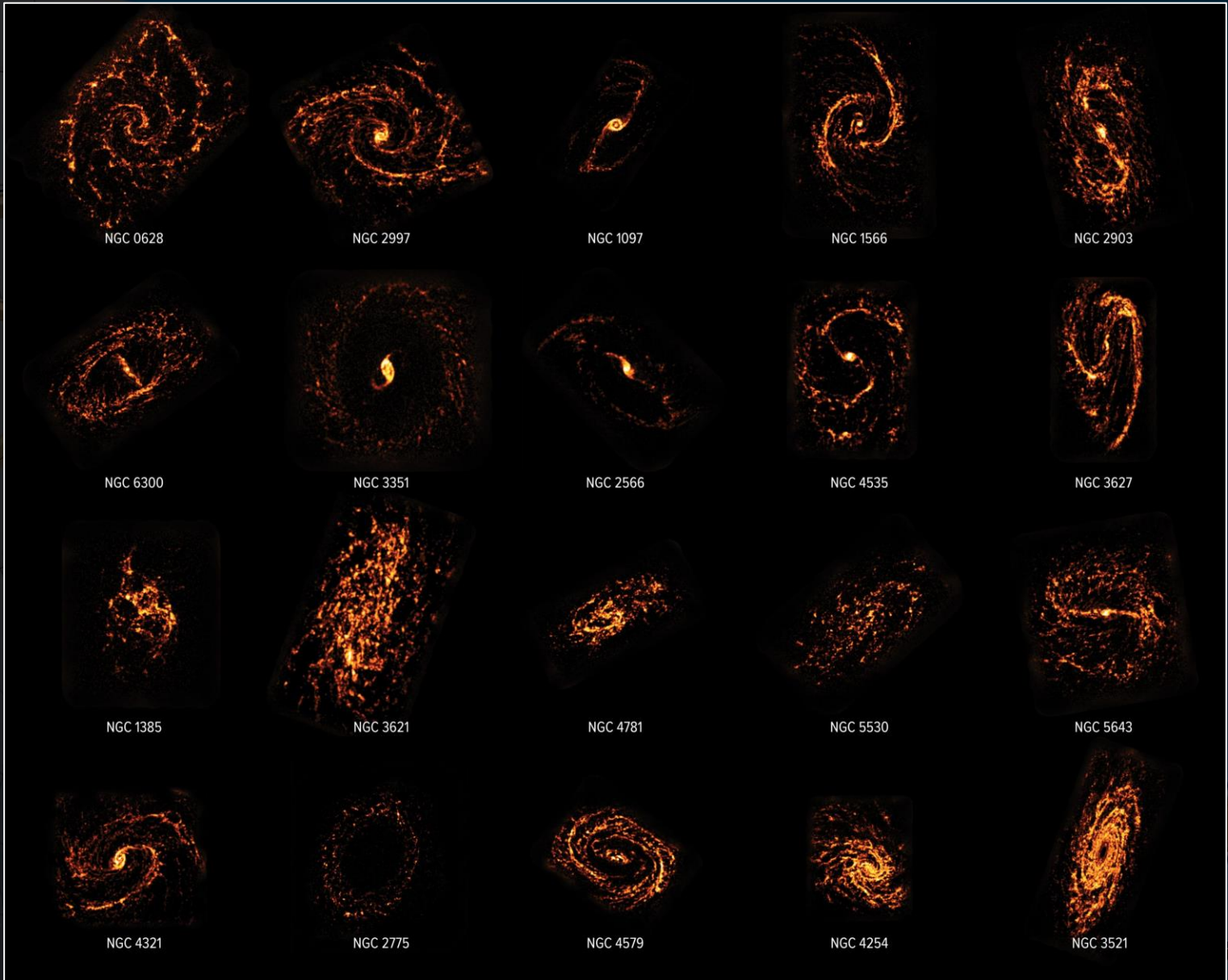




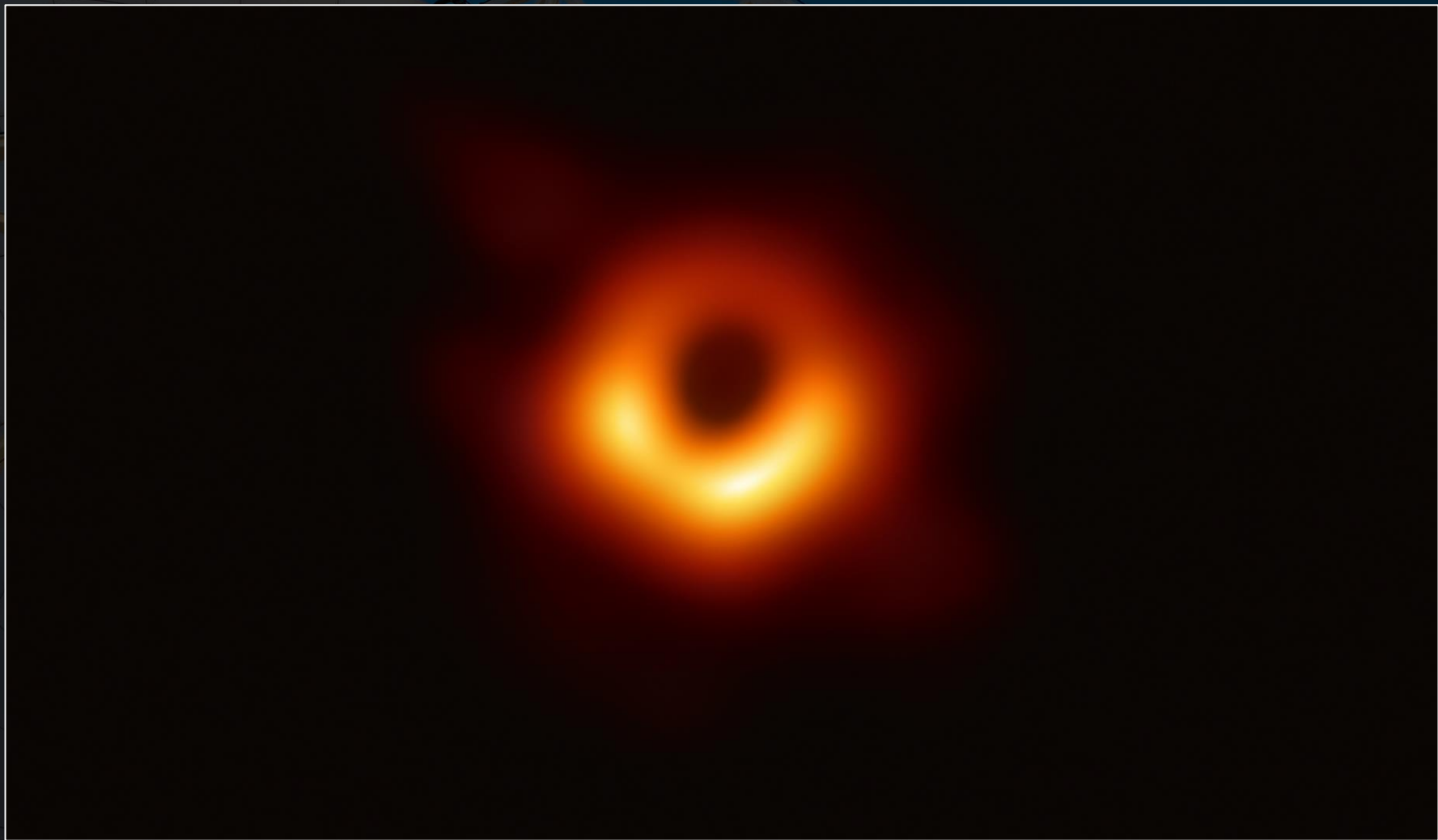
(Credit: ALMA (ESO/NAOJ/NRAO), T. Shimonishi (Niigata University))



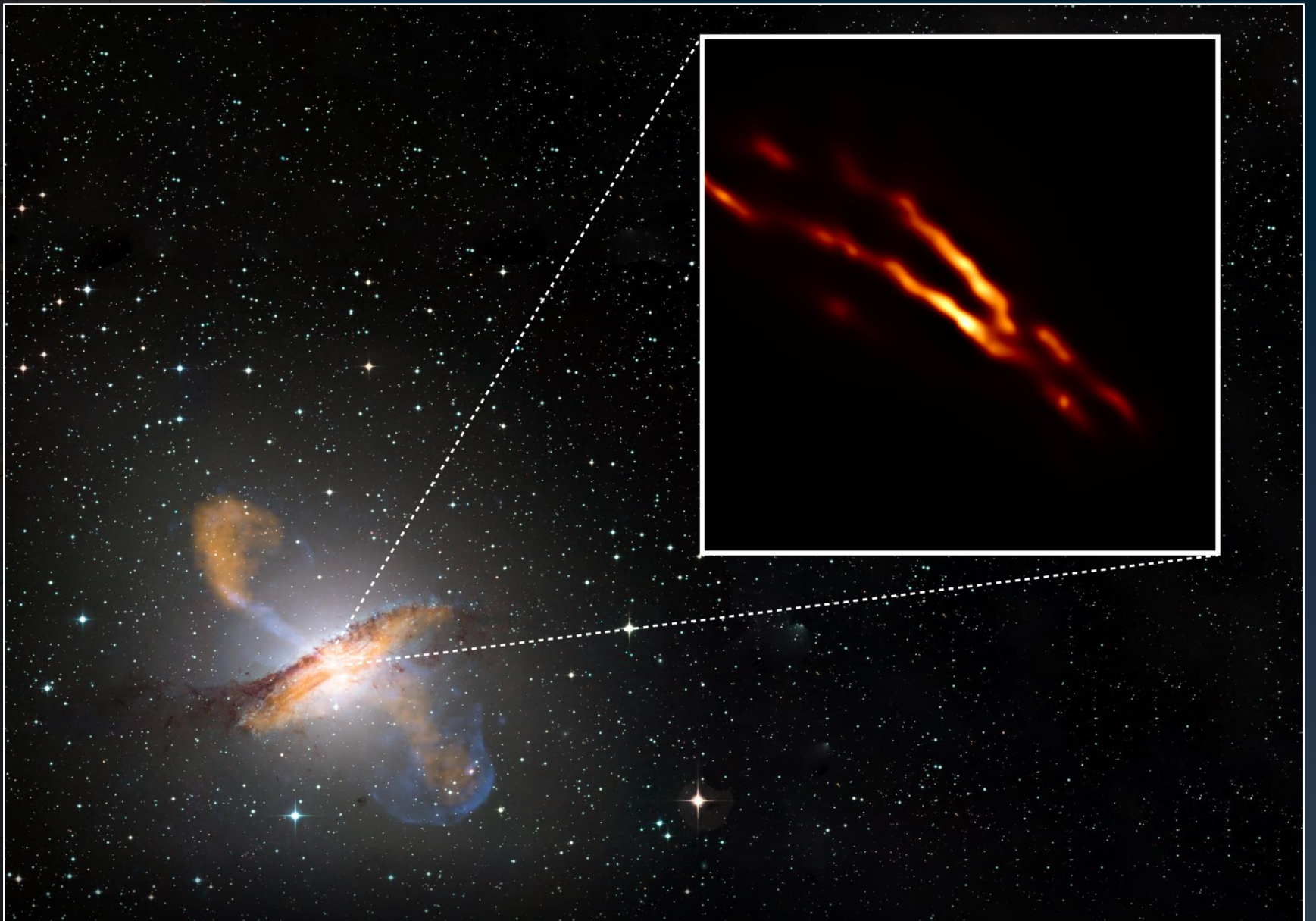
(Credit: L. Decin – ESO – ALMA)



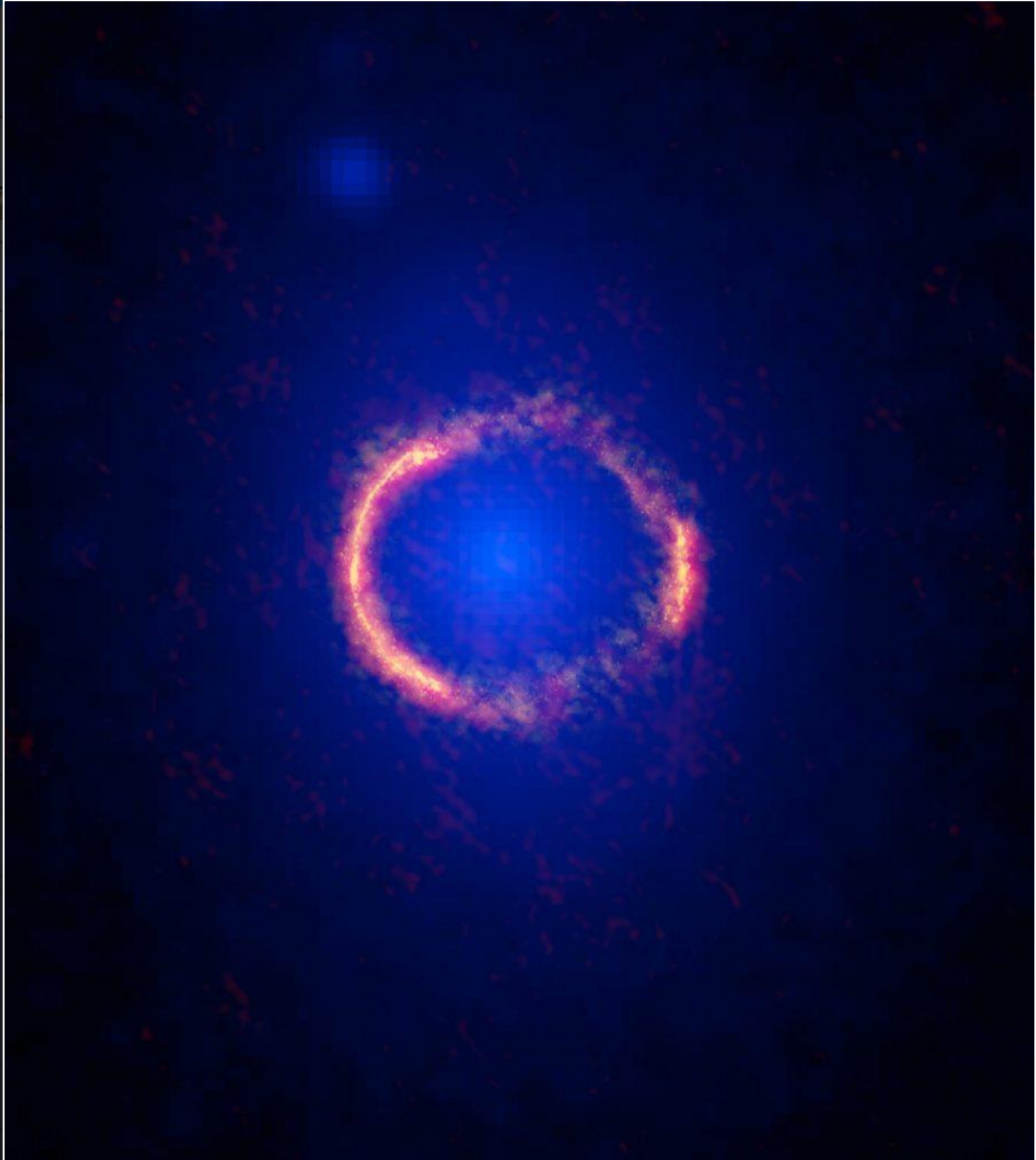
(Credit: ALMA (ESO/NAOJ/NRAO)/PHANGS, S. Dagnello (NRAO))



(Credit: EHT Collaboration)

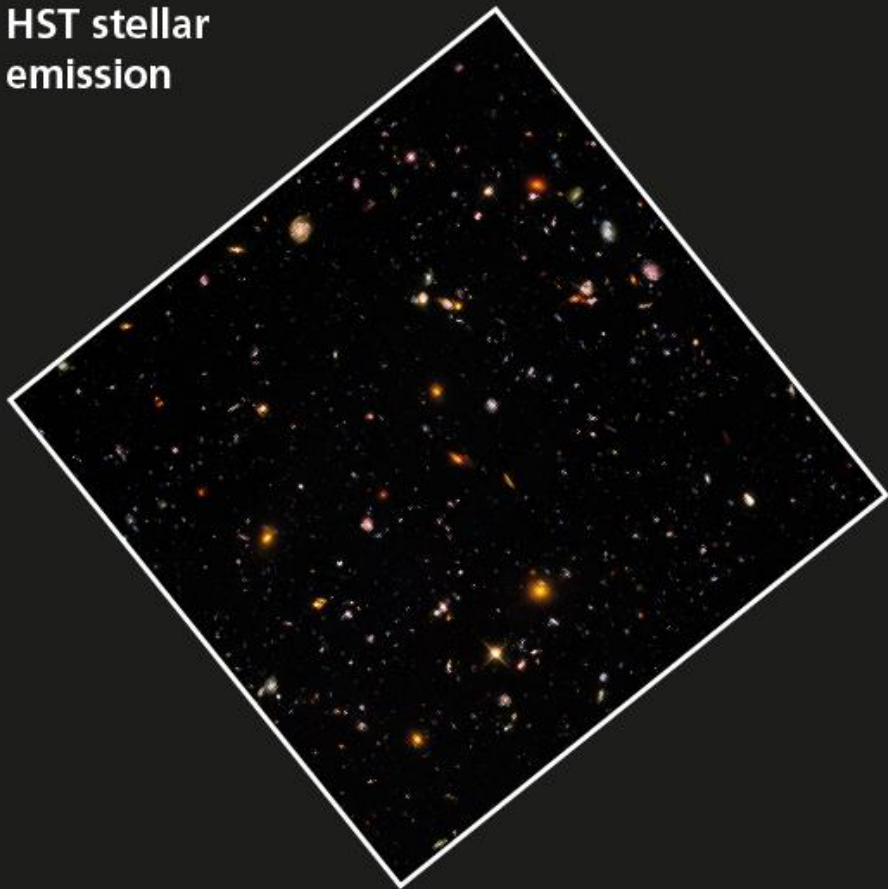


(Credit: Radboud University; ESO/WFI; MPIfR/ESO/APEX/A. Weiss et al.; NASA/CXC/CfA/R. Kraft et al.; EHT/M. Janssen et al.)

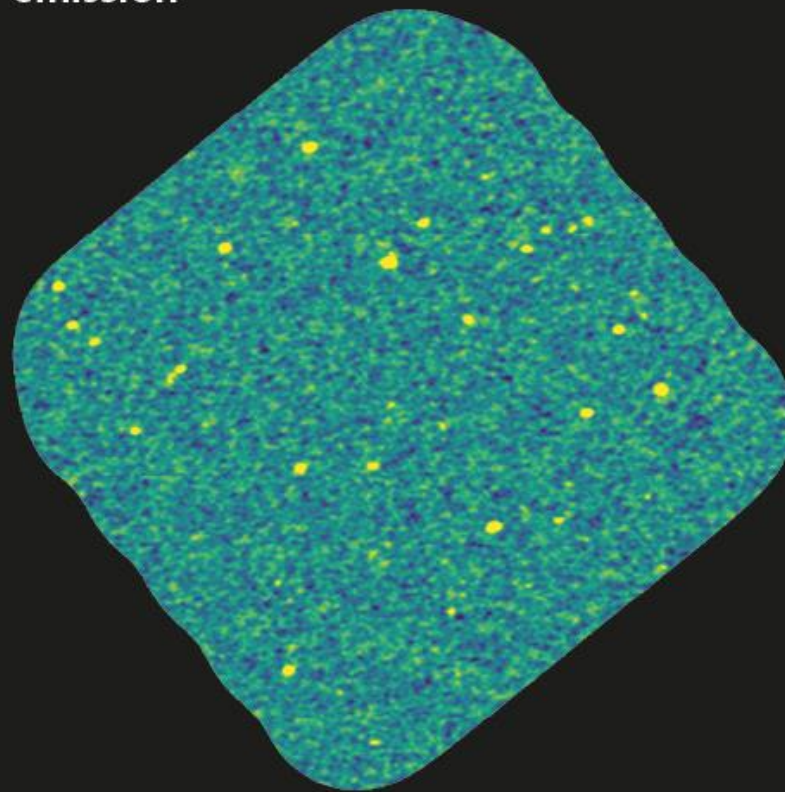


(Credit: ALMA (NRAO/ESO/NAOJ); B. Saxton NRAO/AUI/NSF; NASA/ESA Hubble, T. Hunter (NRAO))

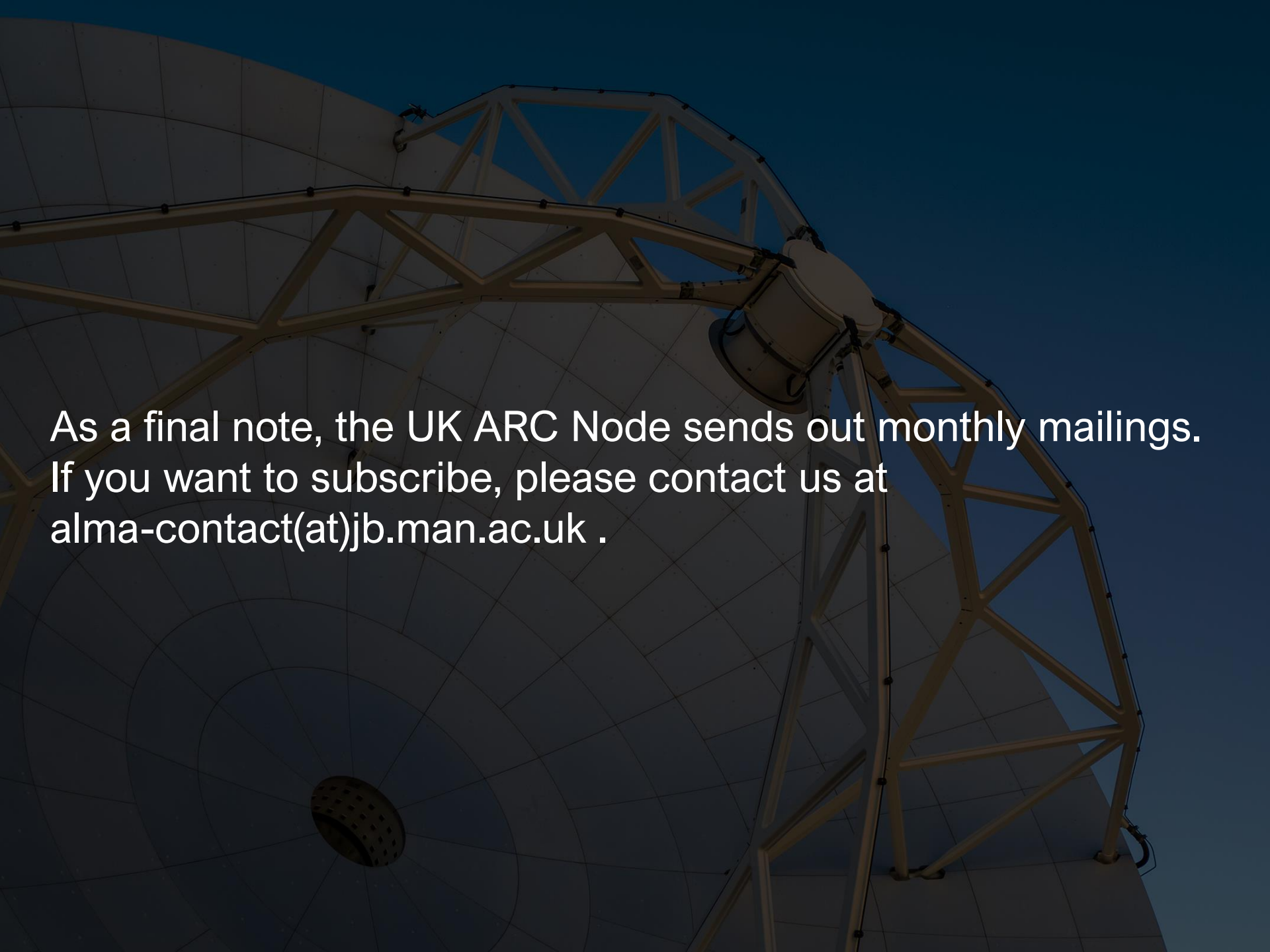
HST stellar  
emission



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 surface made of many small panels, with a complex metal support structure of beams and struts. The sky is a deep, dark blue. The text is overlaid on the left side of the dish.

As a final note, the UK ARC Node sends out monthly mailings.  
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