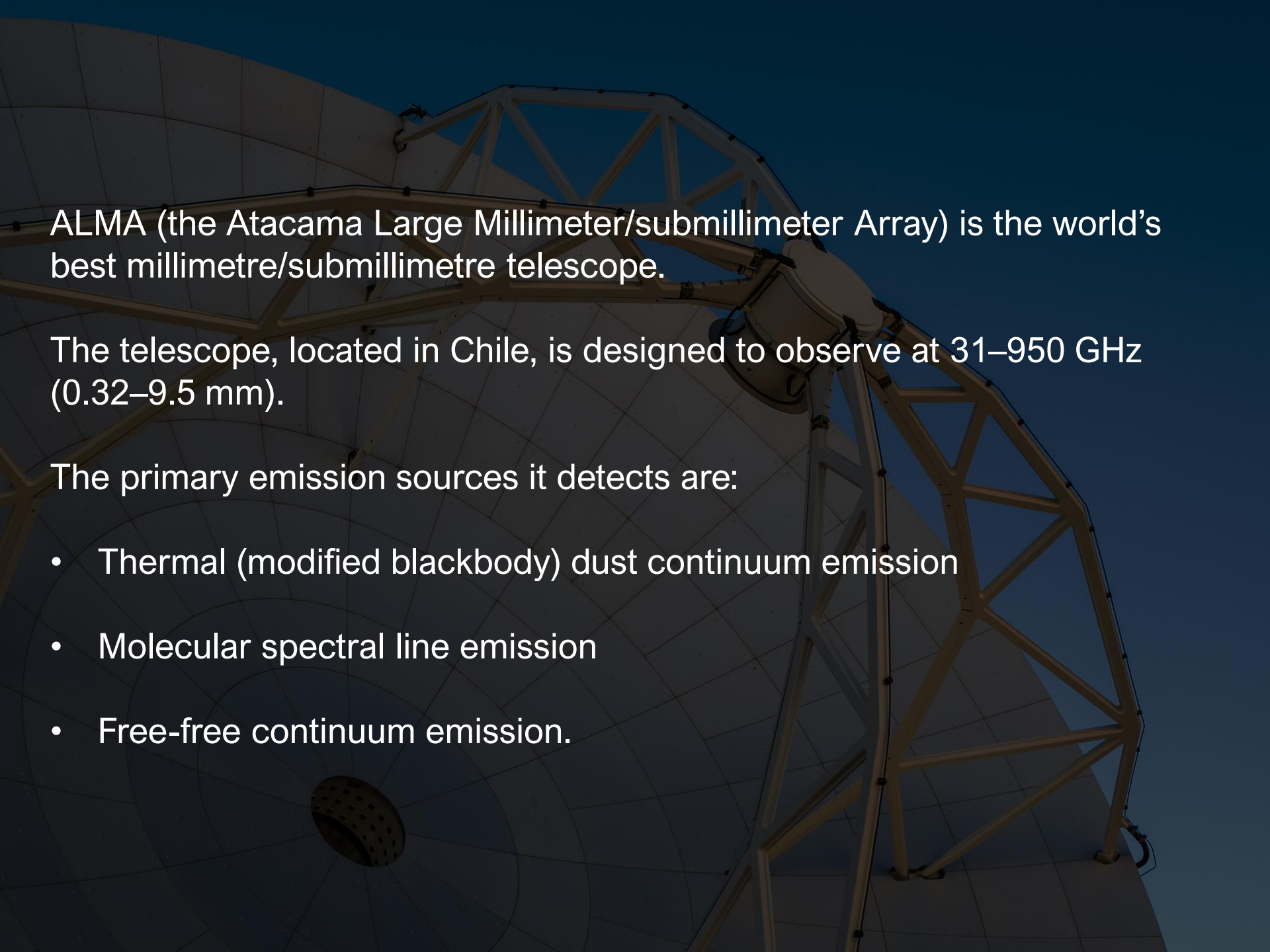
An Introduction to ALMA

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


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 31–950 GHz (0.32–9.5 mm).

The primary emission sources it detects are:

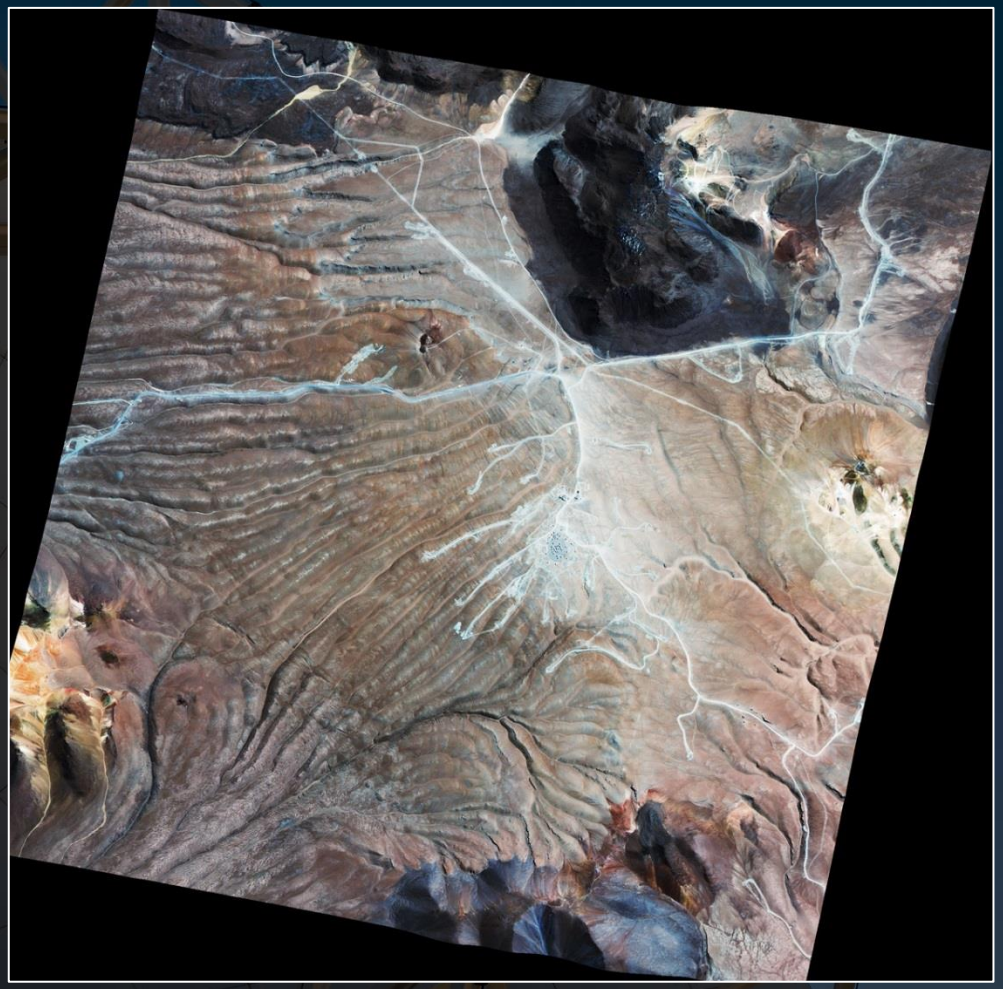
- Thermal (modified blackbody) dust continuum emission
- Molecular spectral line emission
- Free-free continuum emission.

Some of the science performed with ALMA includes:

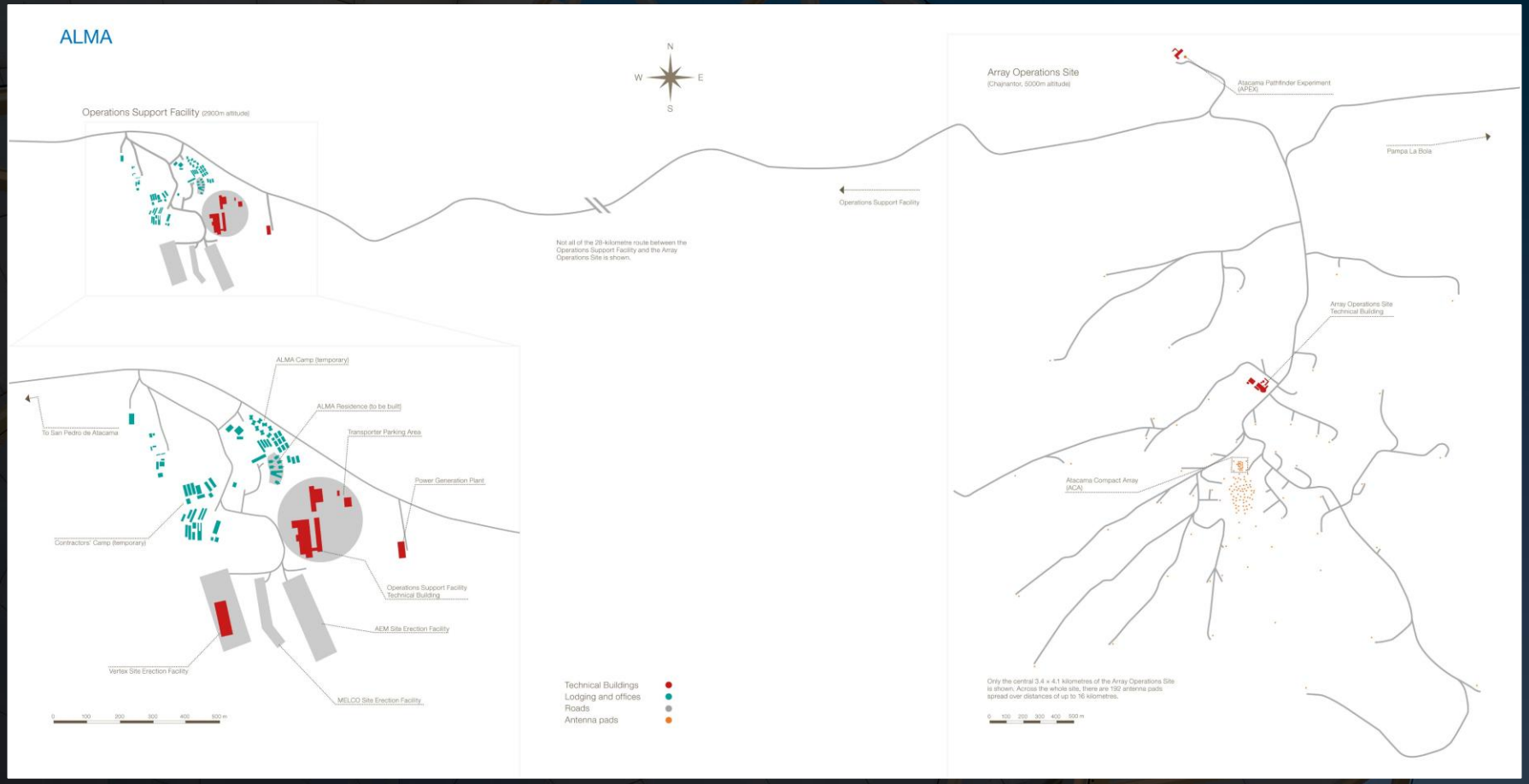
- Detecting dust emission from high-redshift galaxies (up to z=10)
- Using CO to measure redshifts for distant galaxies
- Imaging molecular gas and dust in nearby galaxies
- Examining the formation of protostellar objects in molecular clouds
- Identifying the chemical composition of molecular gas around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

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

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



(Credit: Aerophotogrammetry Sevice, Chilean Air Force)


ALMA
N
W
E
S
Operations Support Facility (2900m altitude)
Operations Support Facility
Not all of the 28-kilometre route between the Operations Support Facility and the Array Operations Site is shown.
Array Operations Site
(Chajnantor, 5000m altitude)
Atacama Pathfinder Experiment (APEX)
Pampa La Bola
Array Operations Site Technical Building
Atacama Compact Array (ACA)
ALMA Camp (temporary)
ALMA Residence (to be built)
To San Pedro de Atacama
Transporter Parking Area
Power Generation Plant
Contractors' Camp (temporary)
Operations Support Facility Technical Building
AEM Site Erection Facility
Vertex Site Erection Facility
MELCO Site Erection Facility
0 100 200 300 400 500 m
Technical Buildings
Lodging and offices
Roads
Antenna pads
Only the central 3.4 × 4.1 kilometres of the Array Operations Site is shown. Across the whole site, there are 192 antenna pads spread over distances of up to 16 kilometres.
0 100 200 300 400 500 m

(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)

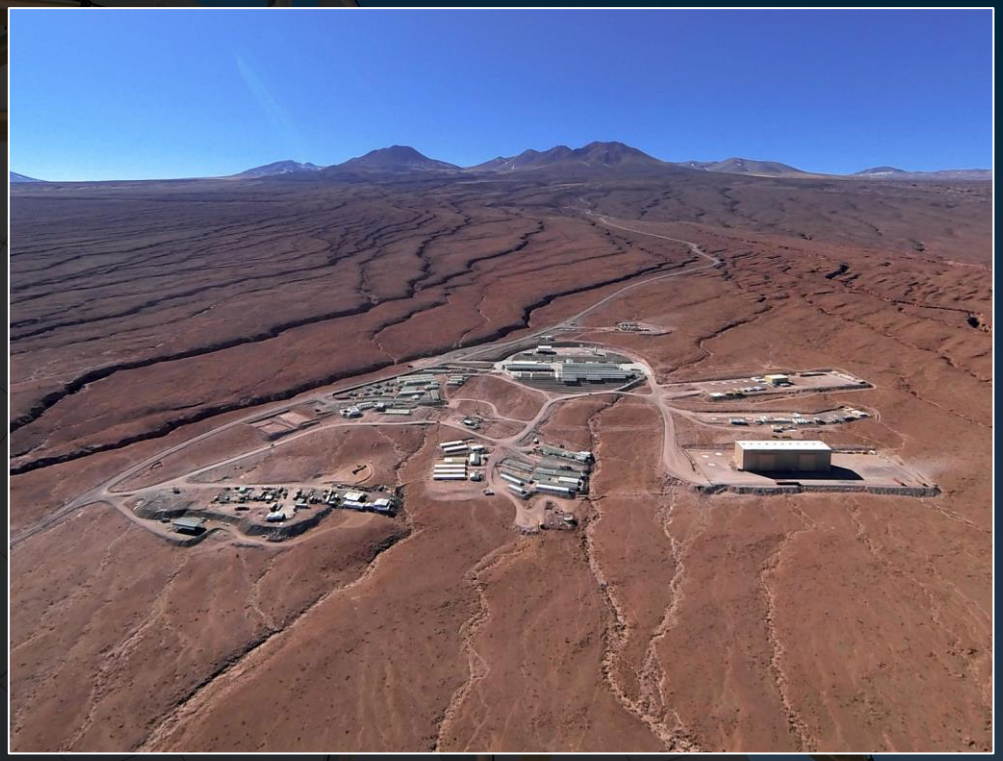
The Array Operations Site (AOS) is located at an elevation of 5000 m.

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.



(Credit: ESO)

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

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)

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.

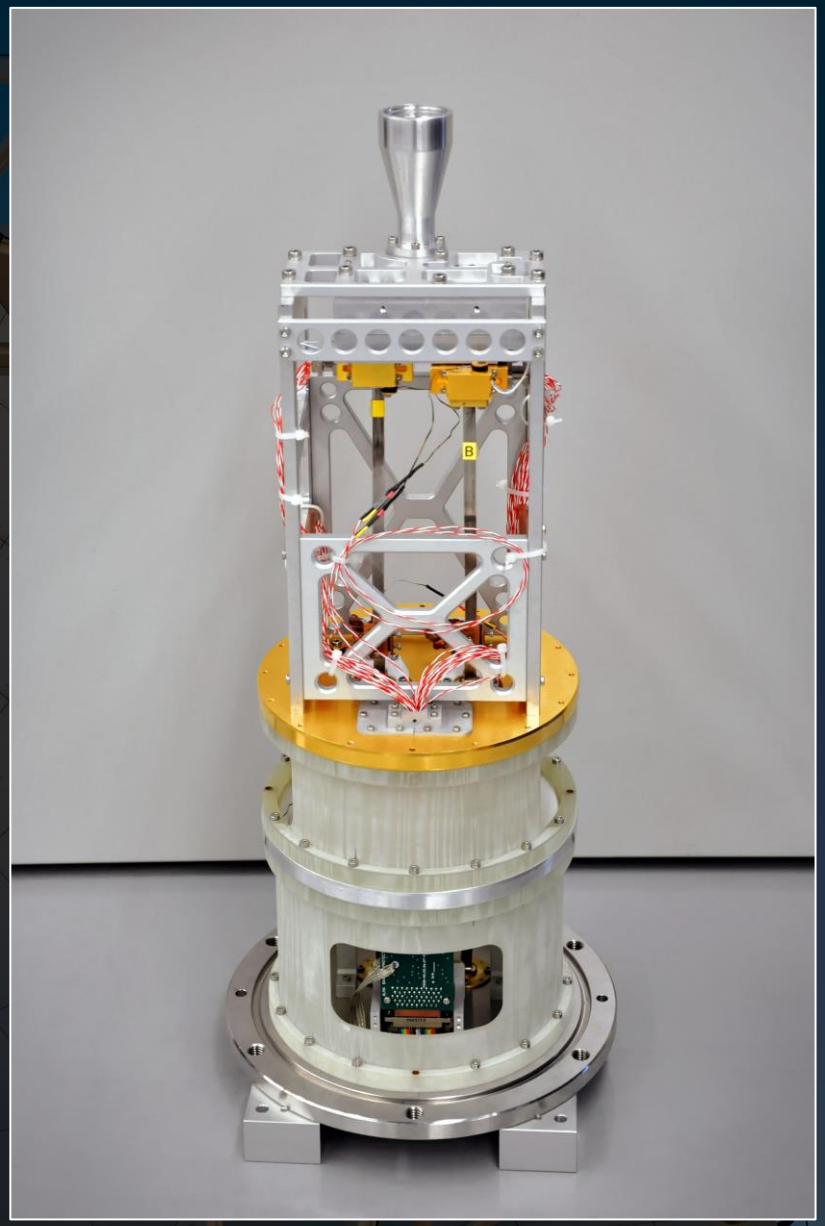
(Credit: ESO)

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.

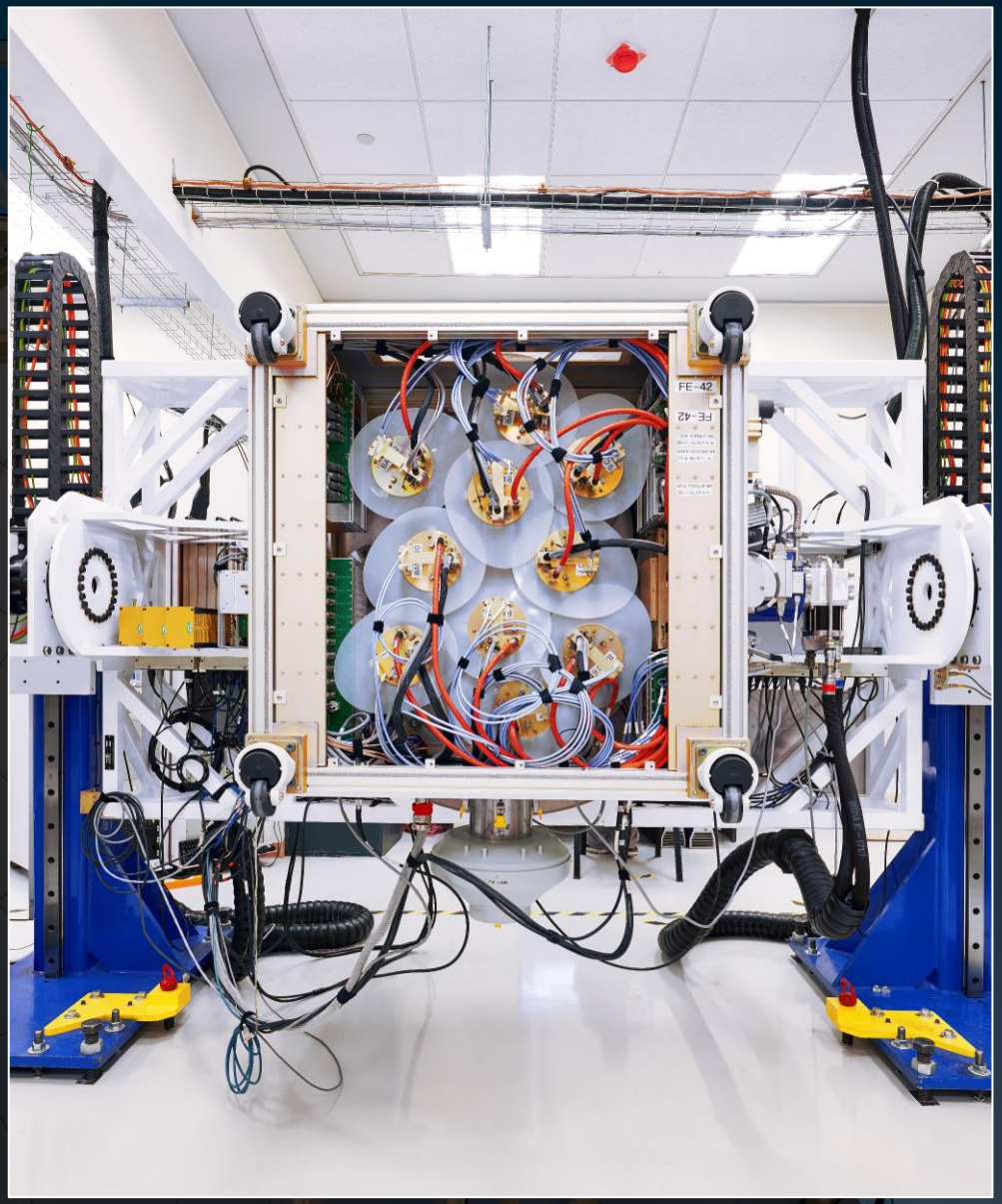
9 bands are available in Cycle 10.



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

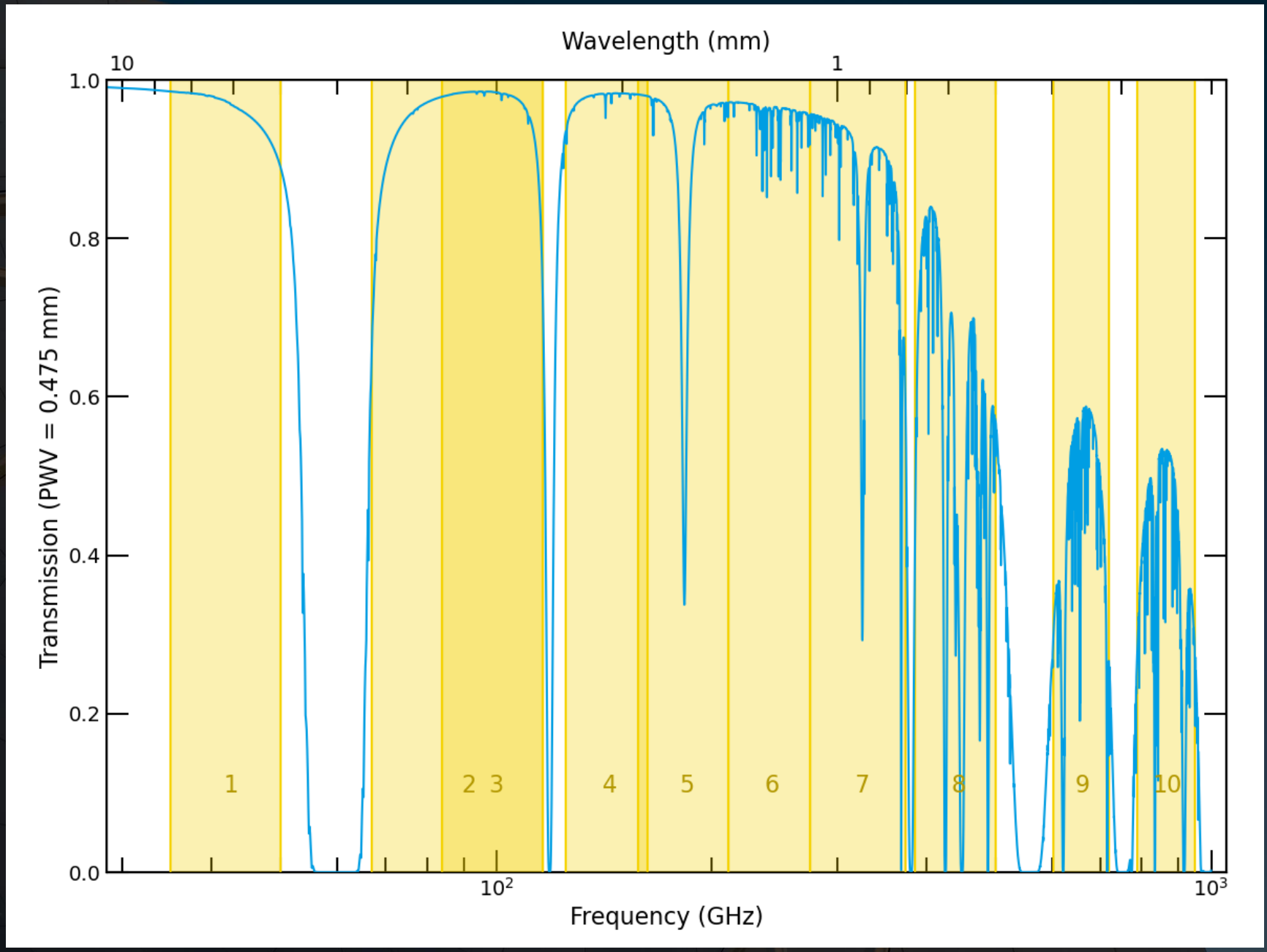
ALMA uses multiple sets of heterodyne receivers.

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


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

ALMA has three subarrays that observe different-sized structures:

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

(Credit: ESO)

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

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

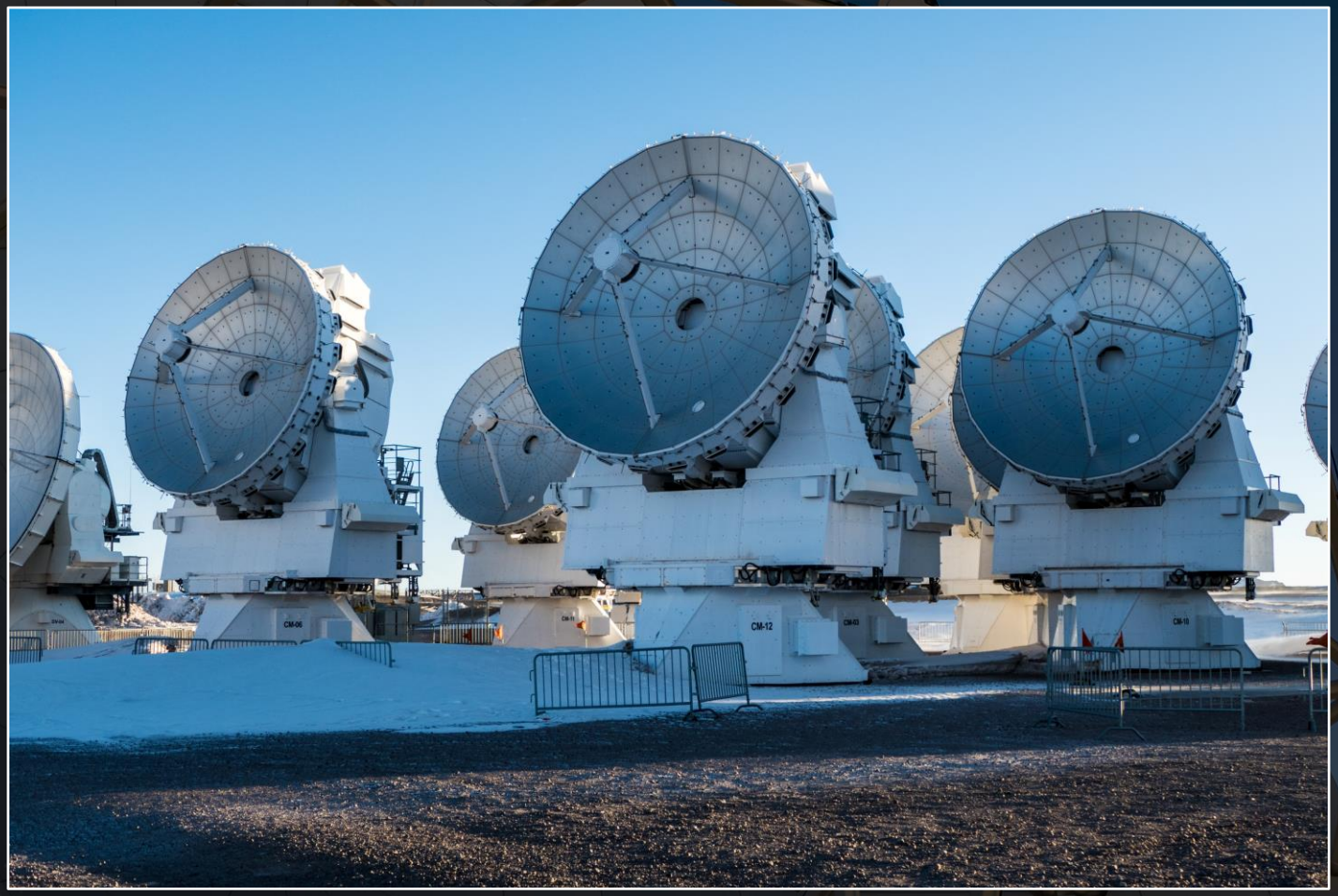
(Credit: ESO/P.Martinez)

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)

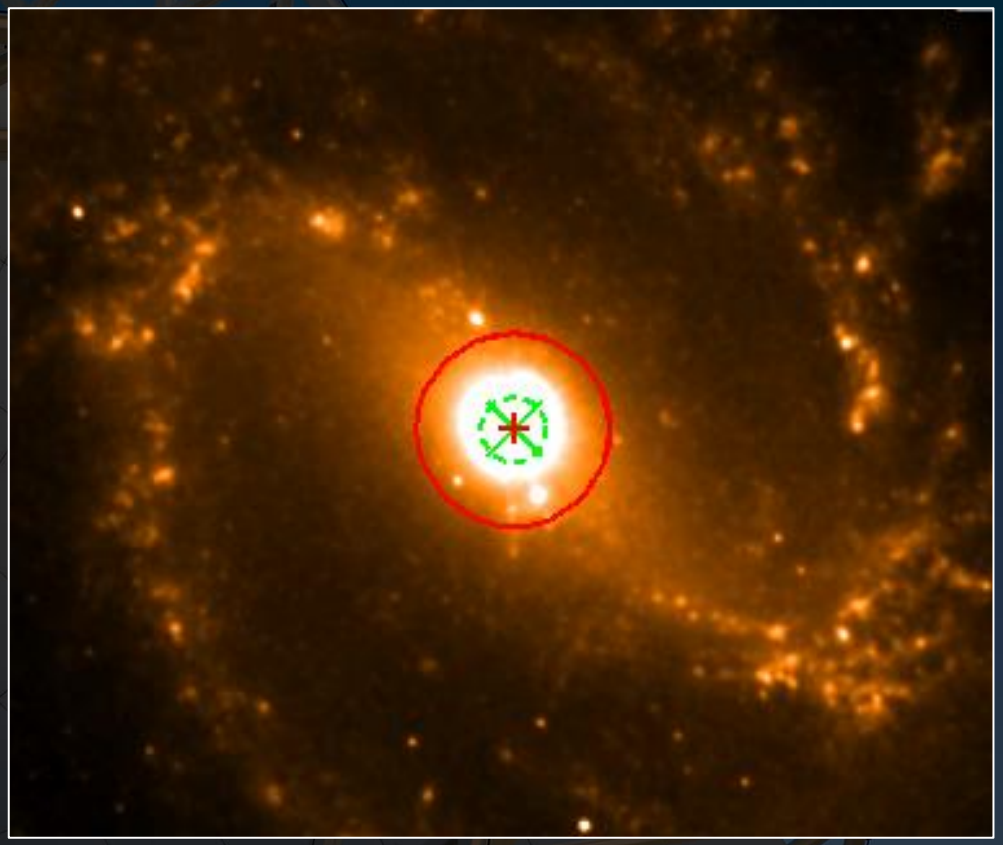
The ACA is used to image large-scale structures that are usually resolved out by the 12m array. It can also be used as a stand-alone array when resolving structure is unimportant.



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.)

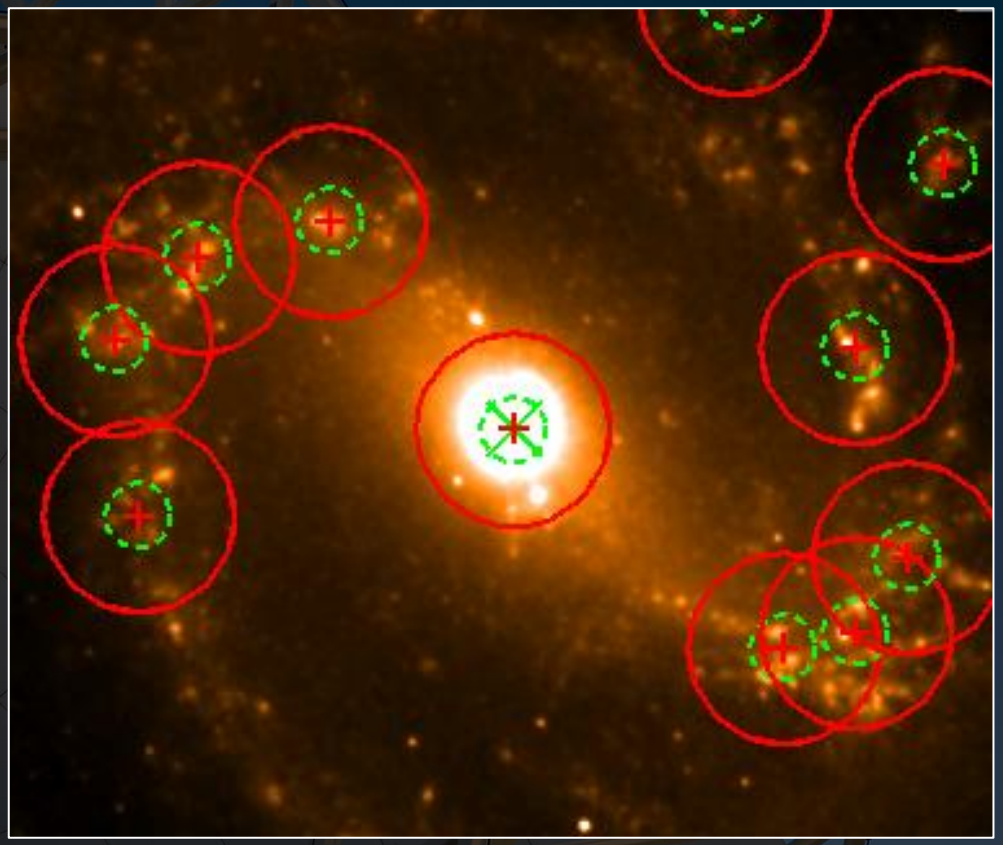
The most basic field that can be imaged by ALMA is a single pointing.

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



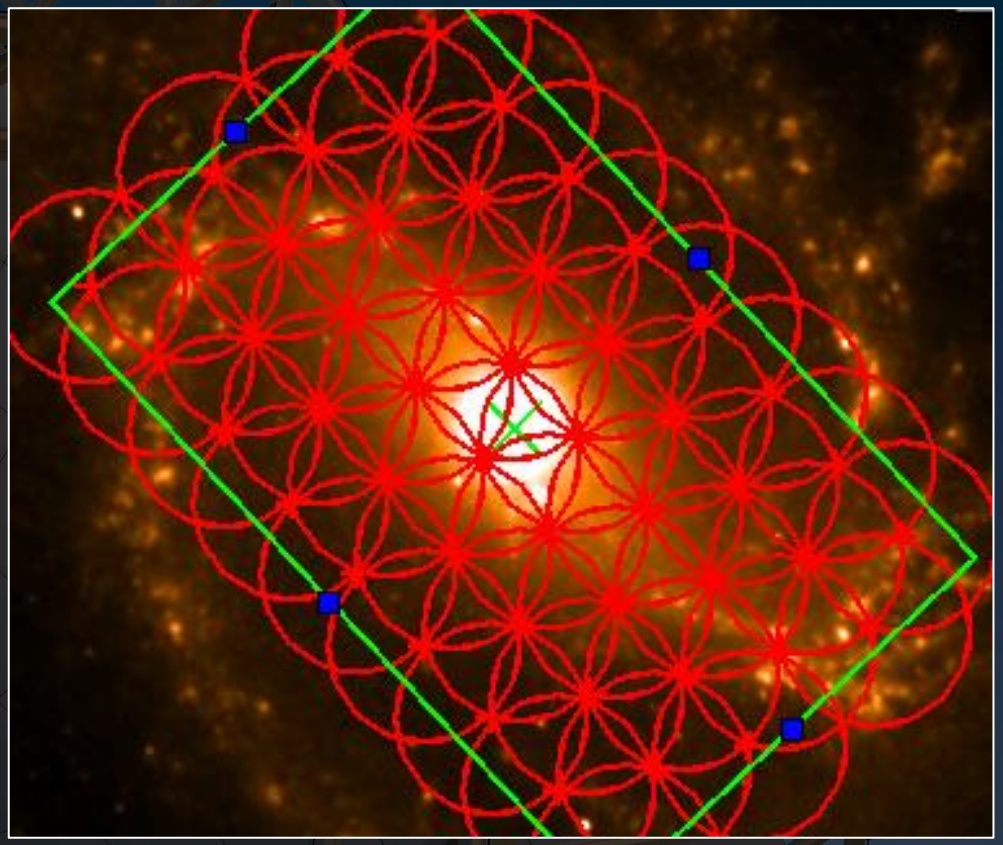
The most basic field that can be imaged by ALMA is a single pointing.

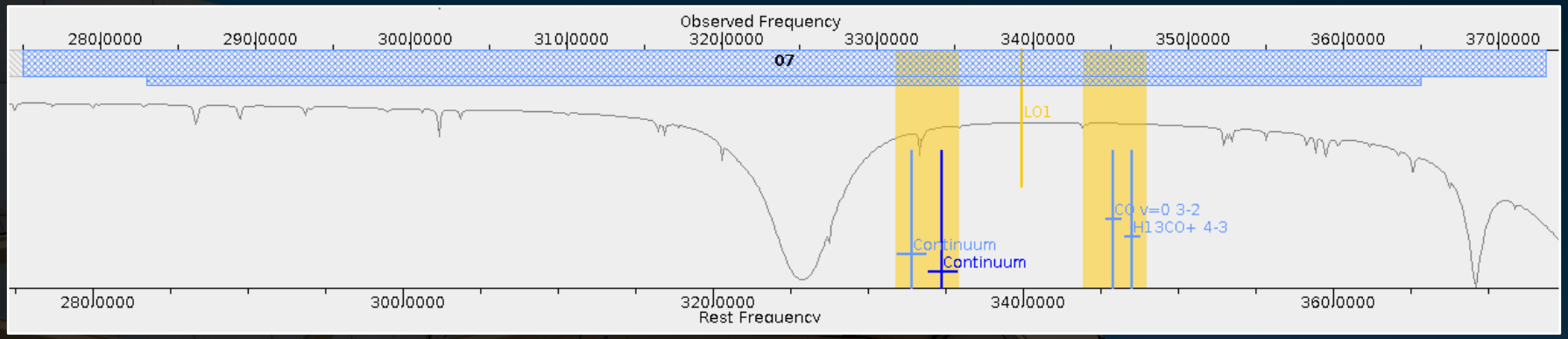
However, ALMA can also image multiple pointings as a set of observations of one target or mosaic a rectangular field.



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.



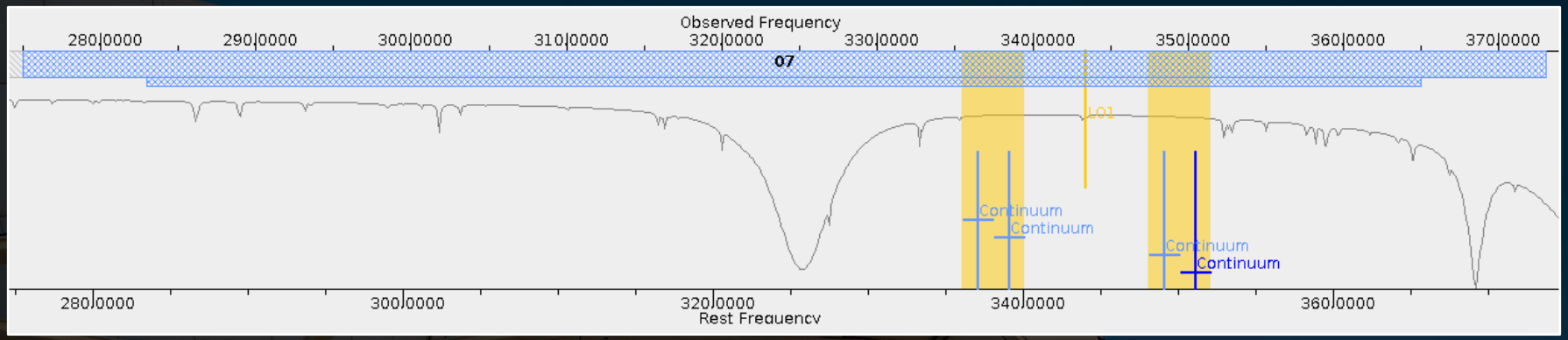


ALMA currently offers three types of spectral set-ups.

- 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).

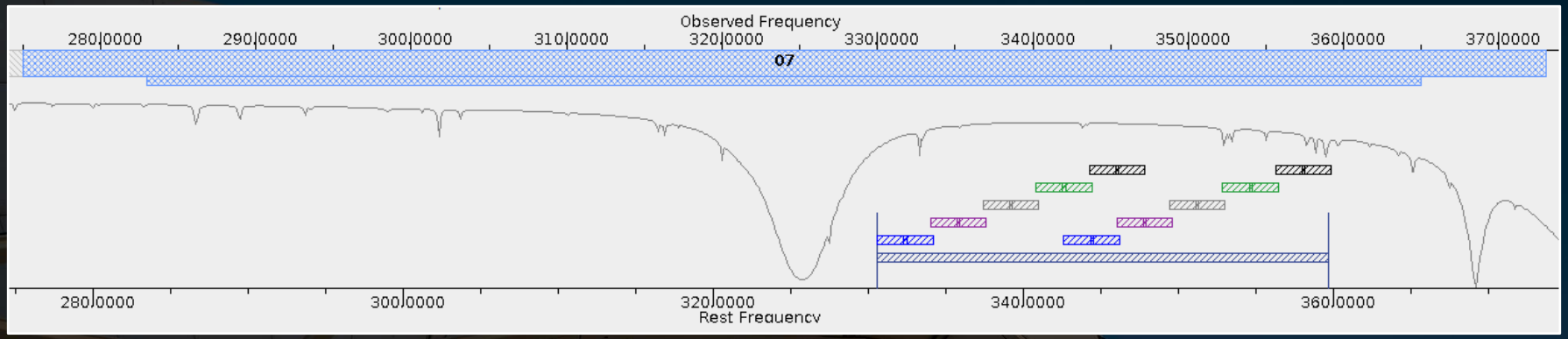


ALMA currently offers three types of spectral set-ups.

- 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).

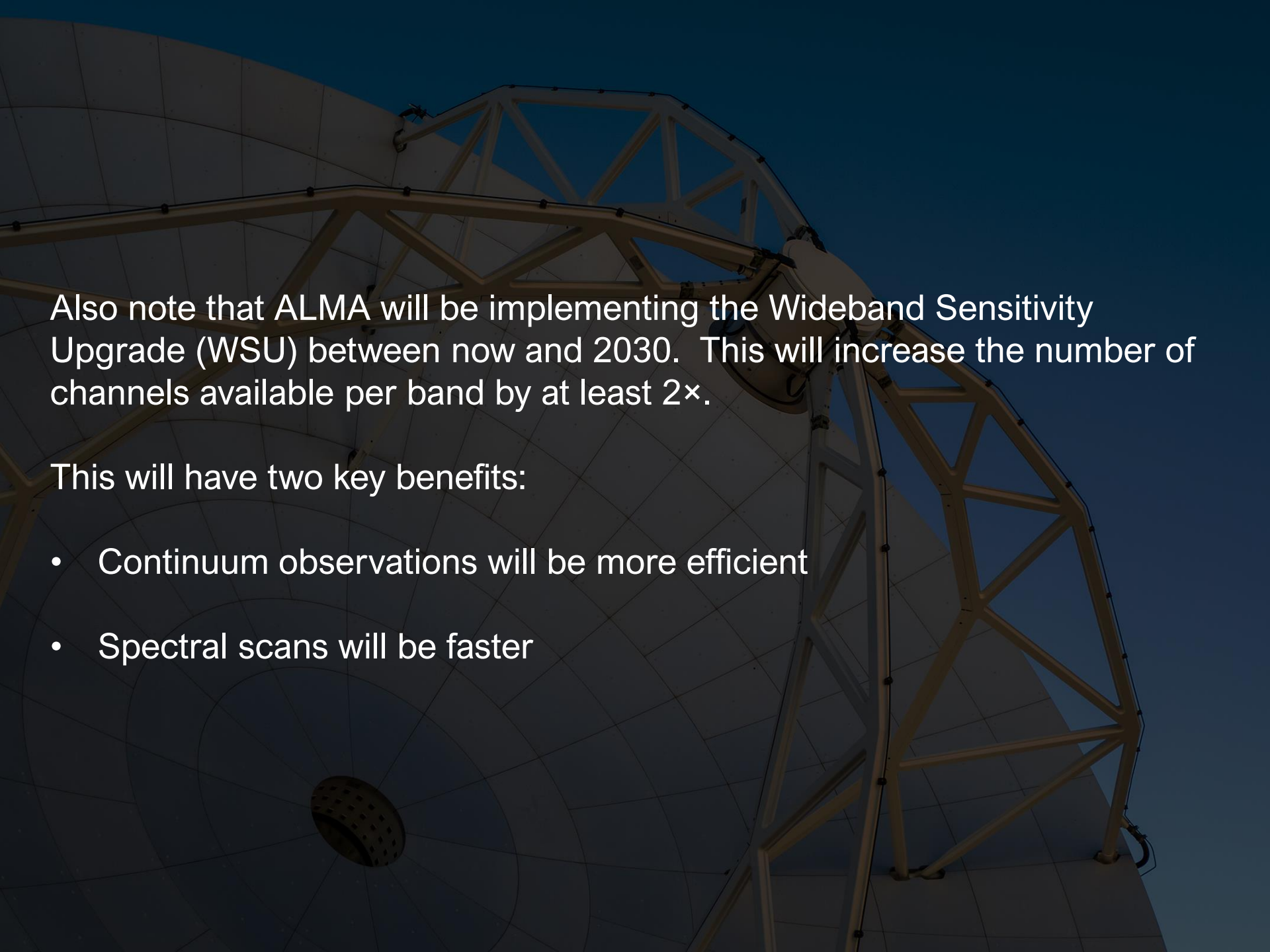


ALMA currently offers three types of spectral set-ups.

- 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).

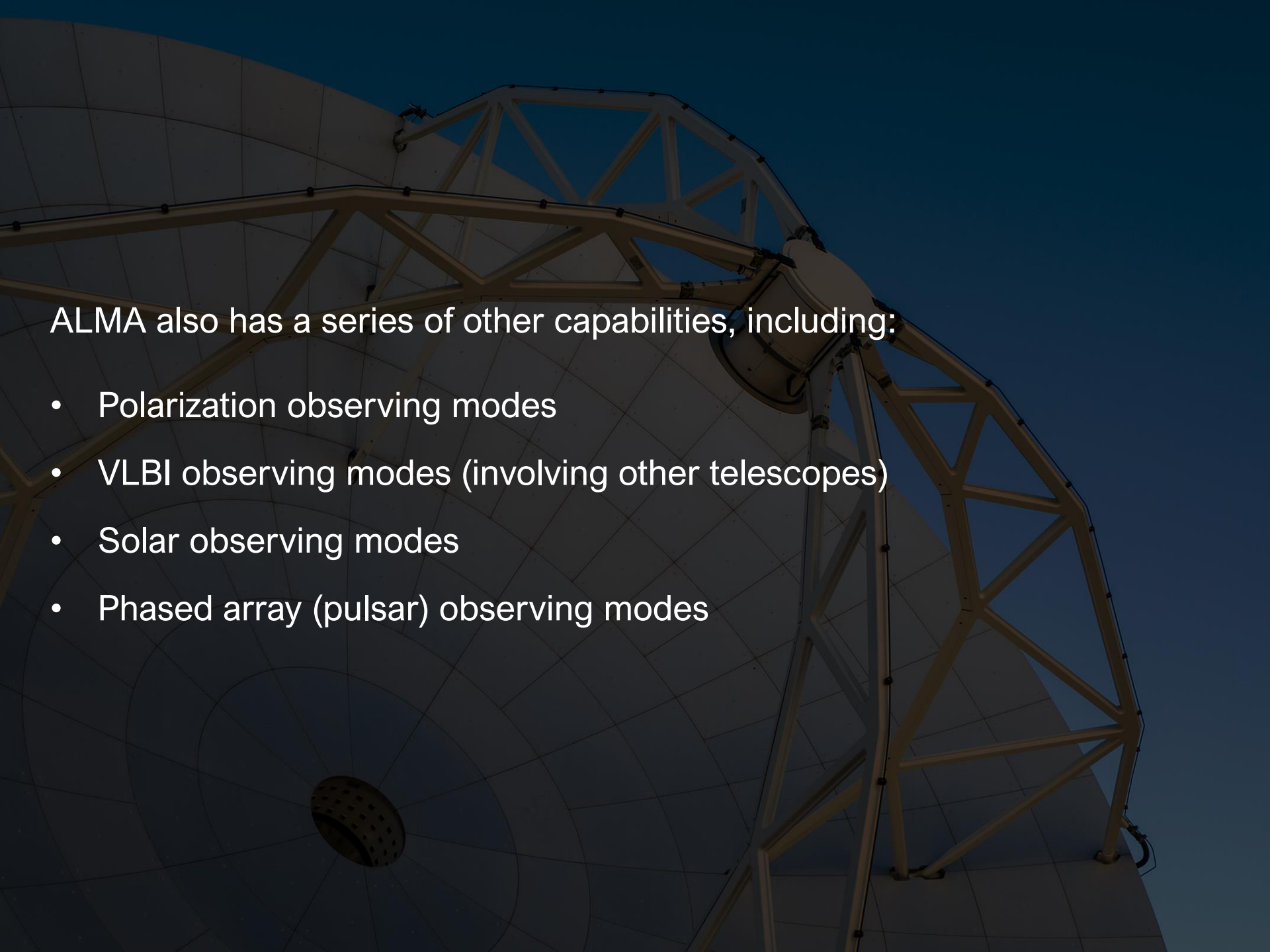
Each spw can contain up to 3840 channels (or 4096 for the ACA).



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

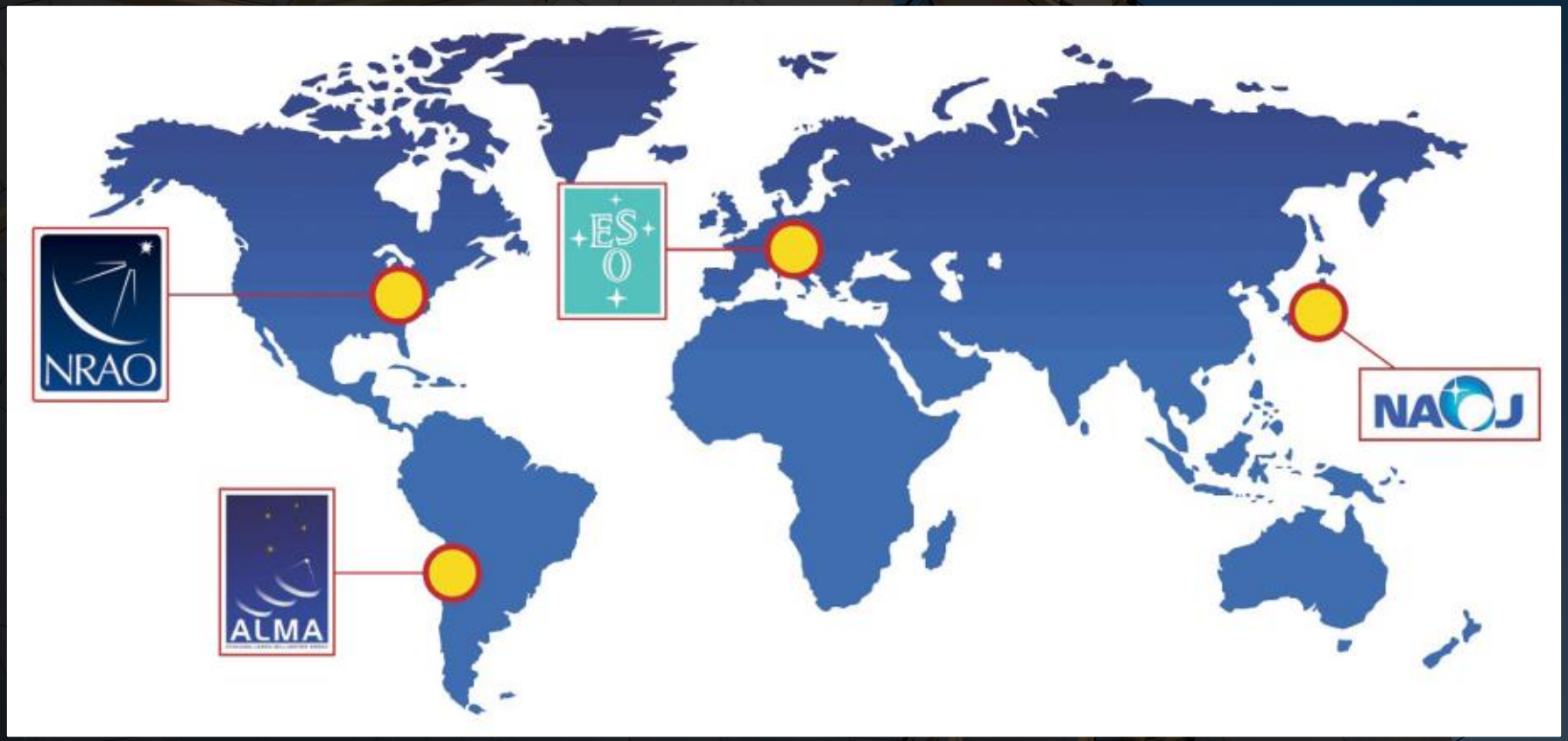


ALMA also has a series of other capabilities, including:

- 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).

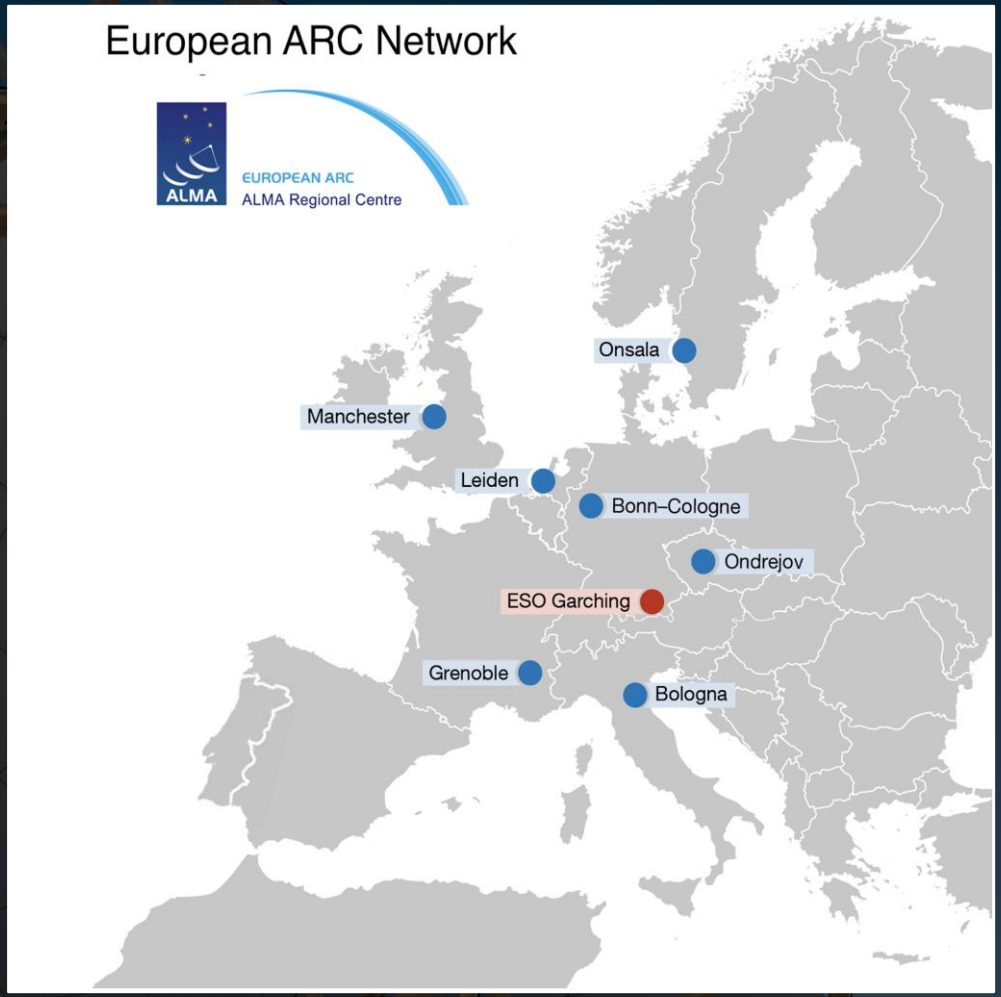
The Joint ALMA Office (JAO) in Chile coordinates all activities.



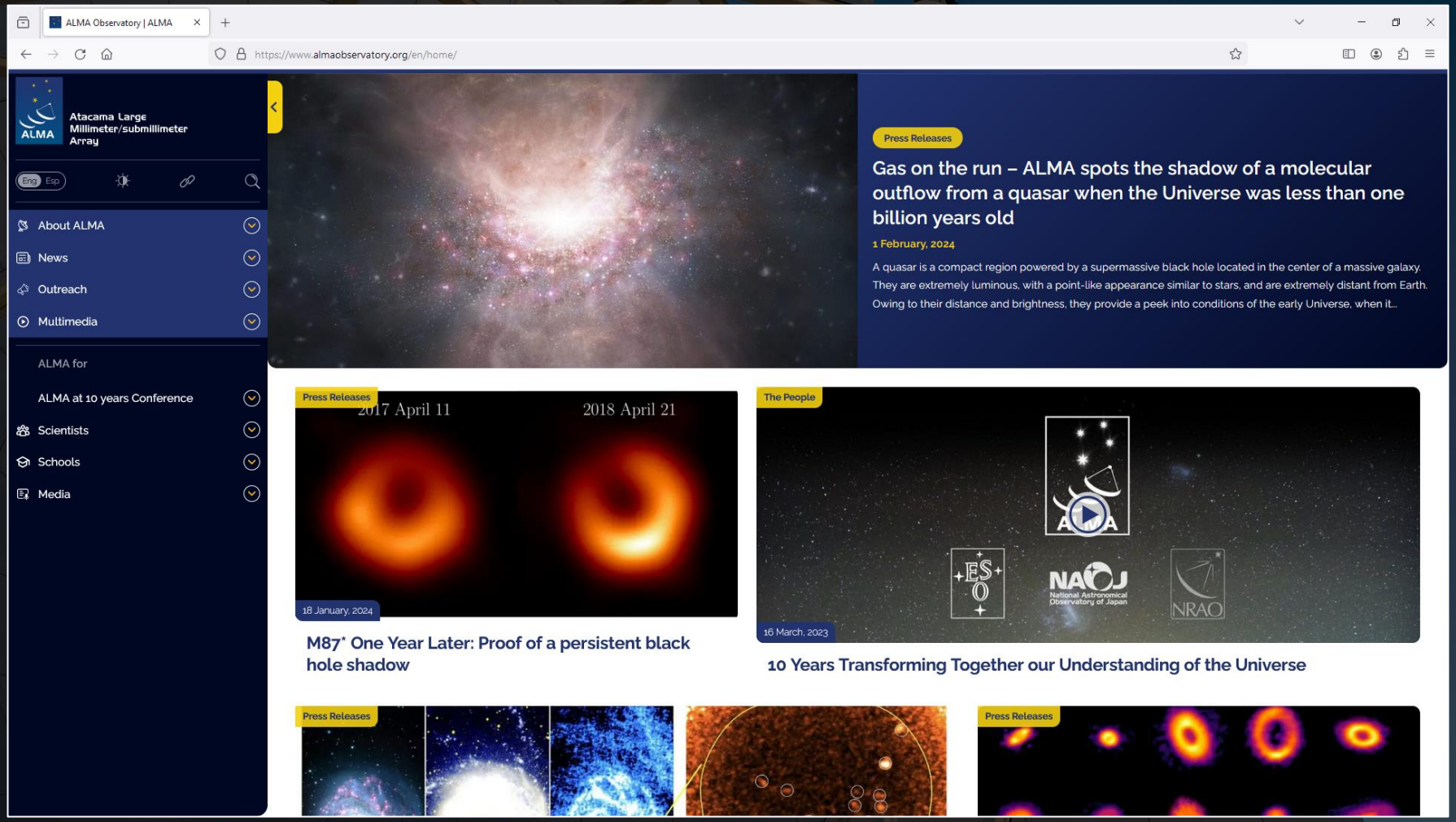
The European Southern Observatory coordinates ALMA activities in Europe.

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

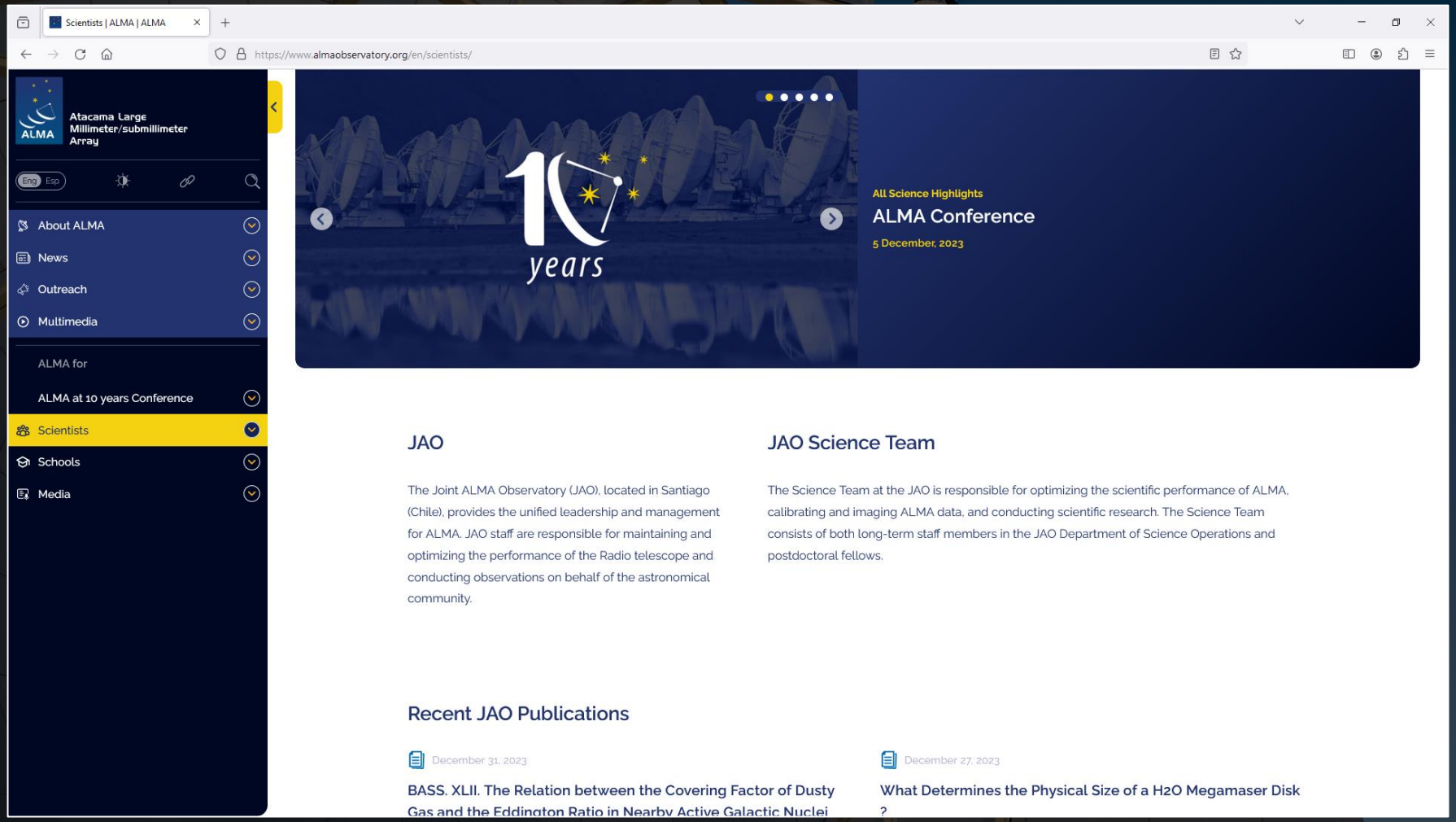
The University of Manchester hosts the ARC Node for the United Kingdom.



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



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



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

Home — ALMA Science Portal

https://almascience.eso.org

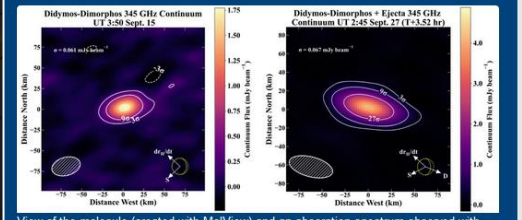
Atacama Large Millimeter/submillimeter Array

In search of our Cosmic Origins

About Science Proposing Observing Data Processing Tools Documentation Help

Science Highlight

Protonated acetylene in the z=0.89 absorber toward PKS1830-211



View of the molecule (created with MolView) and an absorption spectrum observed with ALMA in the line of sight of the quasar PKS1830-211. The quasar (here observed with the MERLIN interferometer at radio wavelengths) is lensed by a foreground spiral galaxy at z=0.89 (optical image from HST).

The line of sight to the lensed blazar PKS1830-211 intercepts the disk of a foreground spiral galaxy at z=0.89 where absorption has been detected for more than 60 molecular species, mostly at mm wavelengths. In a paper accepted for publication in A&A. Dr. Sebastian Muller and colleagues report the detection of a new interstellar molecule, protonated acetylene C2H3+, based on ALMA observations of this absorber. The molecule has been suspected to be present in the interstellar medium for a long time, but it has eluded detection so far due to the unfavourable frequencies of its rotational spectrum. Thanks to the redshift of the absorber, the ground-state transitions of both ortho and para forms could be detected in ALMA high-sensitivity spectra. As one of the initial hydrocarbon building...

More...

Observatory News

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

Release of Solar Full Polarization ALMA Test Data
Nov 06, 2023

More...

EU ARC News

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

Postdoctoral position(s) at the Allegro ARC node at

More...

ALMA Status

Configuration Schedule

Refereed publications: 3641
Last observed source: NGC 7252E
Current configuration: C-3

More...

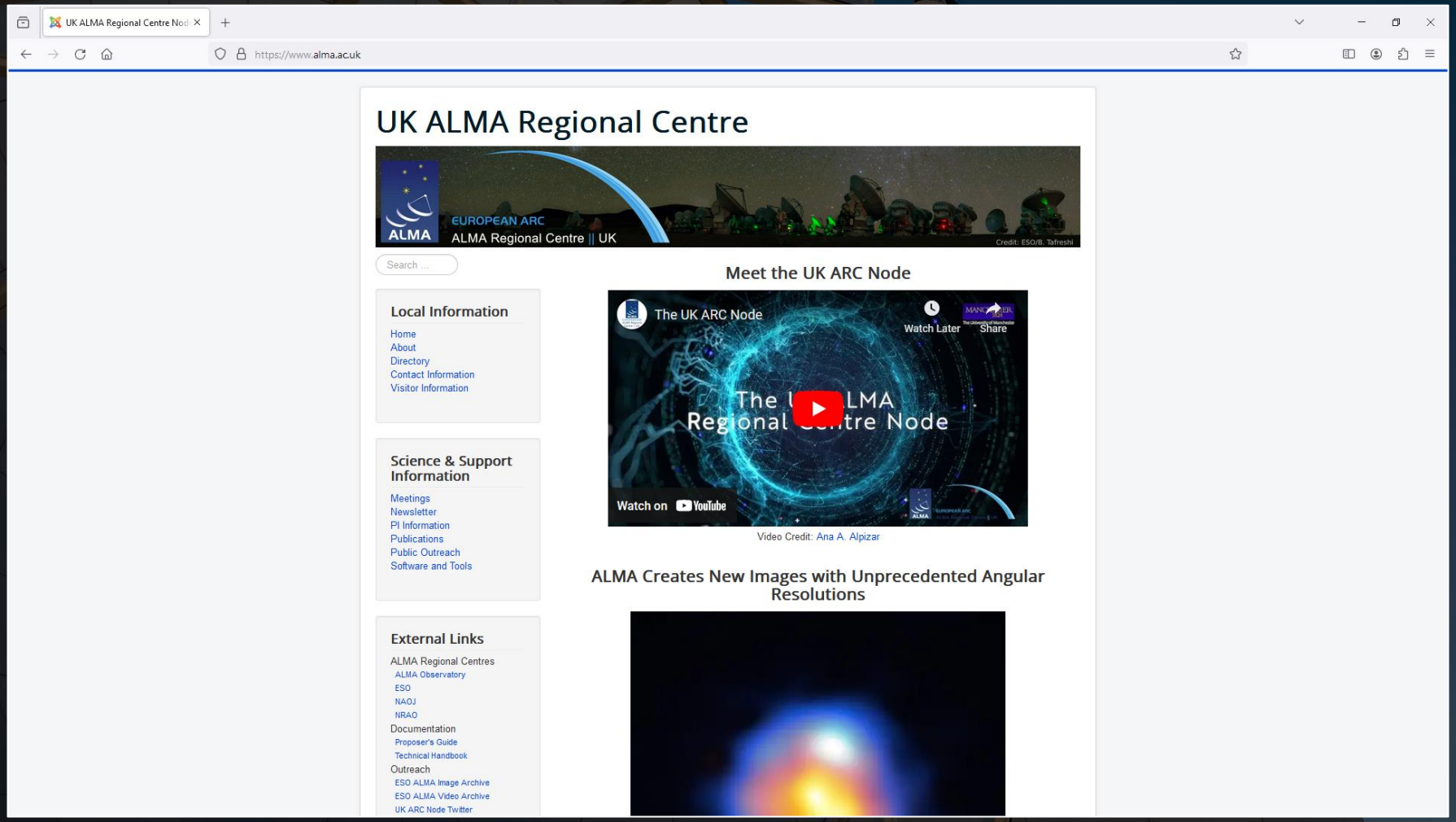
The ALMA Science Portal is a one-stop source for information and tools aimed at the scientific community as a whole, including proposers, archive researchers, ALMA staff, journalists, and funding agencies.

Quick Links

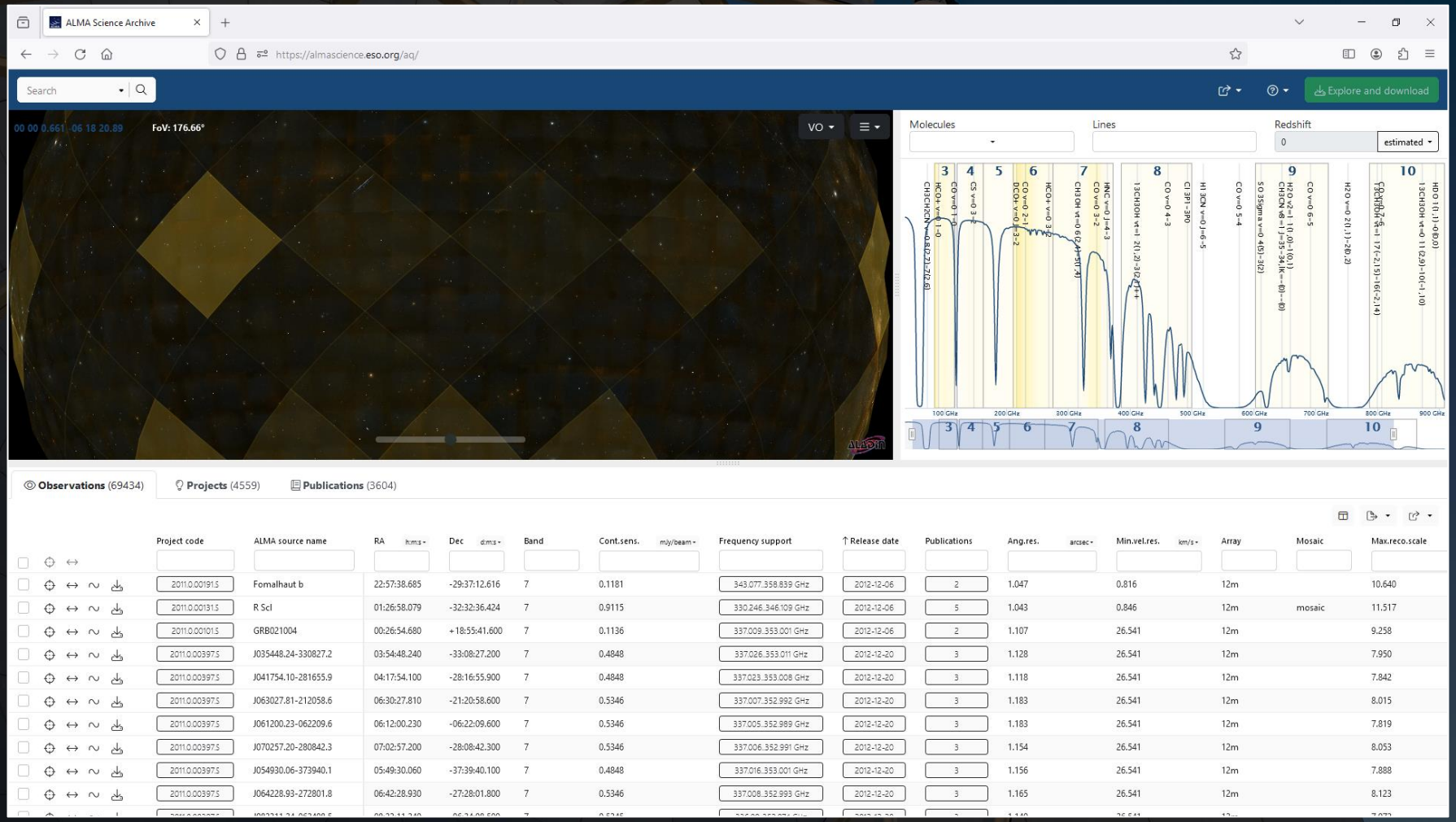
ALMA Basics	Configuration Schedule
ALMA Science	SnooPI
ALMA Primer	DDT Proposals

Site Map Accessibility Contact Privacy Statement Region: EA EU NA

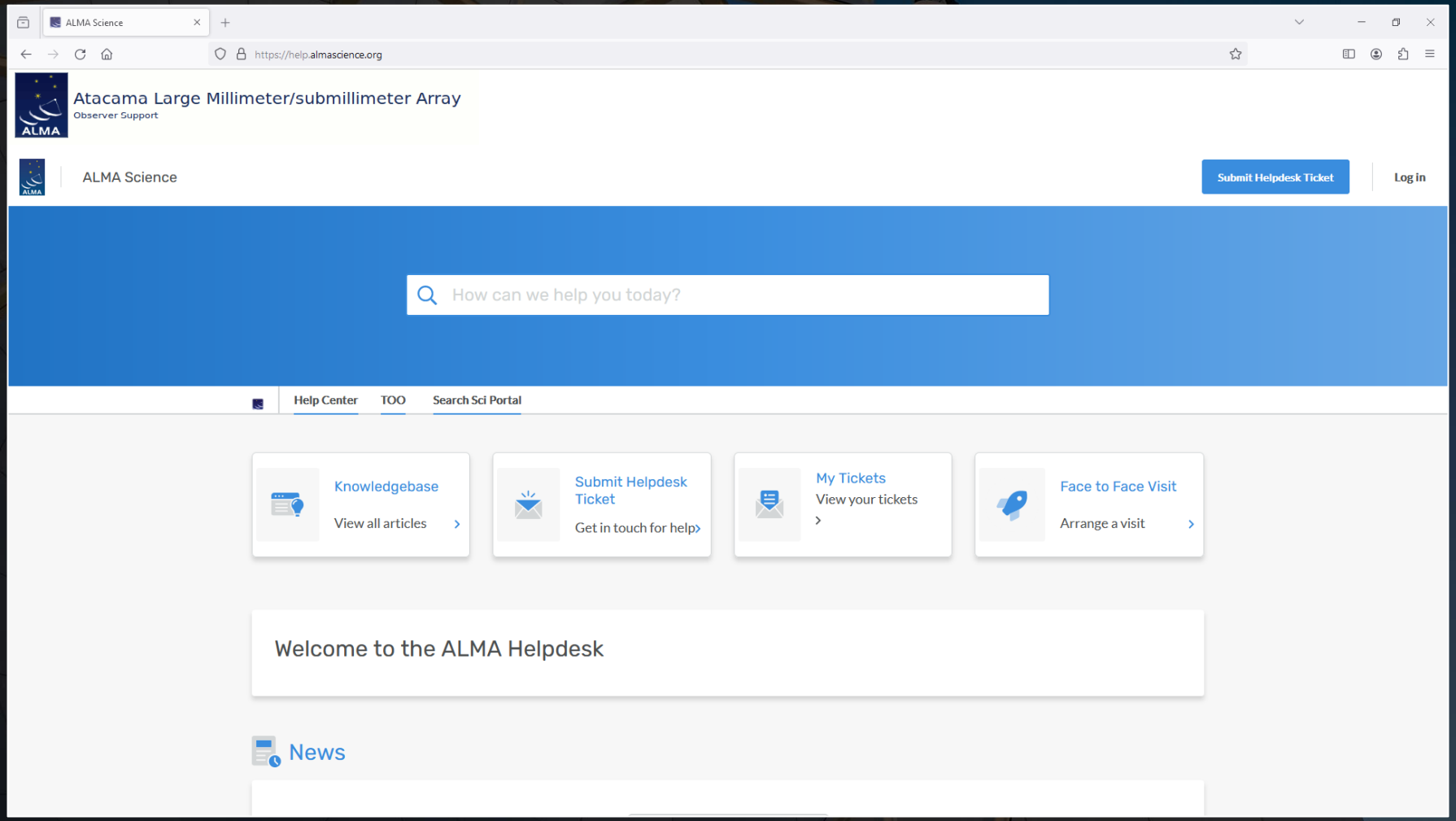
The UK ARC Node has a website at https://www.alma.ac.uk that provides news and information for UK ALMA users.



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

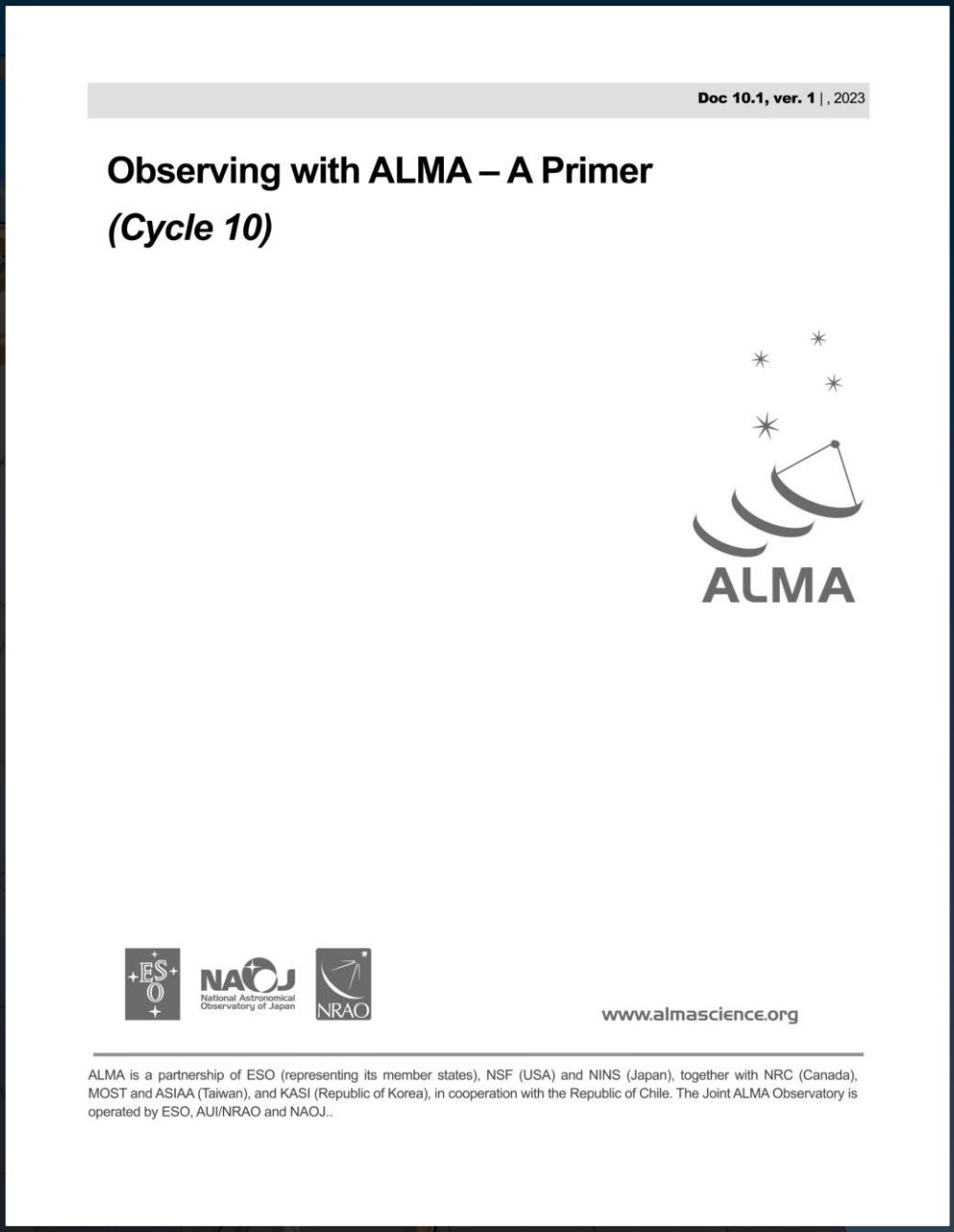


The best way to communicate with ALMA staff (including the UK ARC Node) is to use the ALMA Helpdesk at https://help.almascience.org.



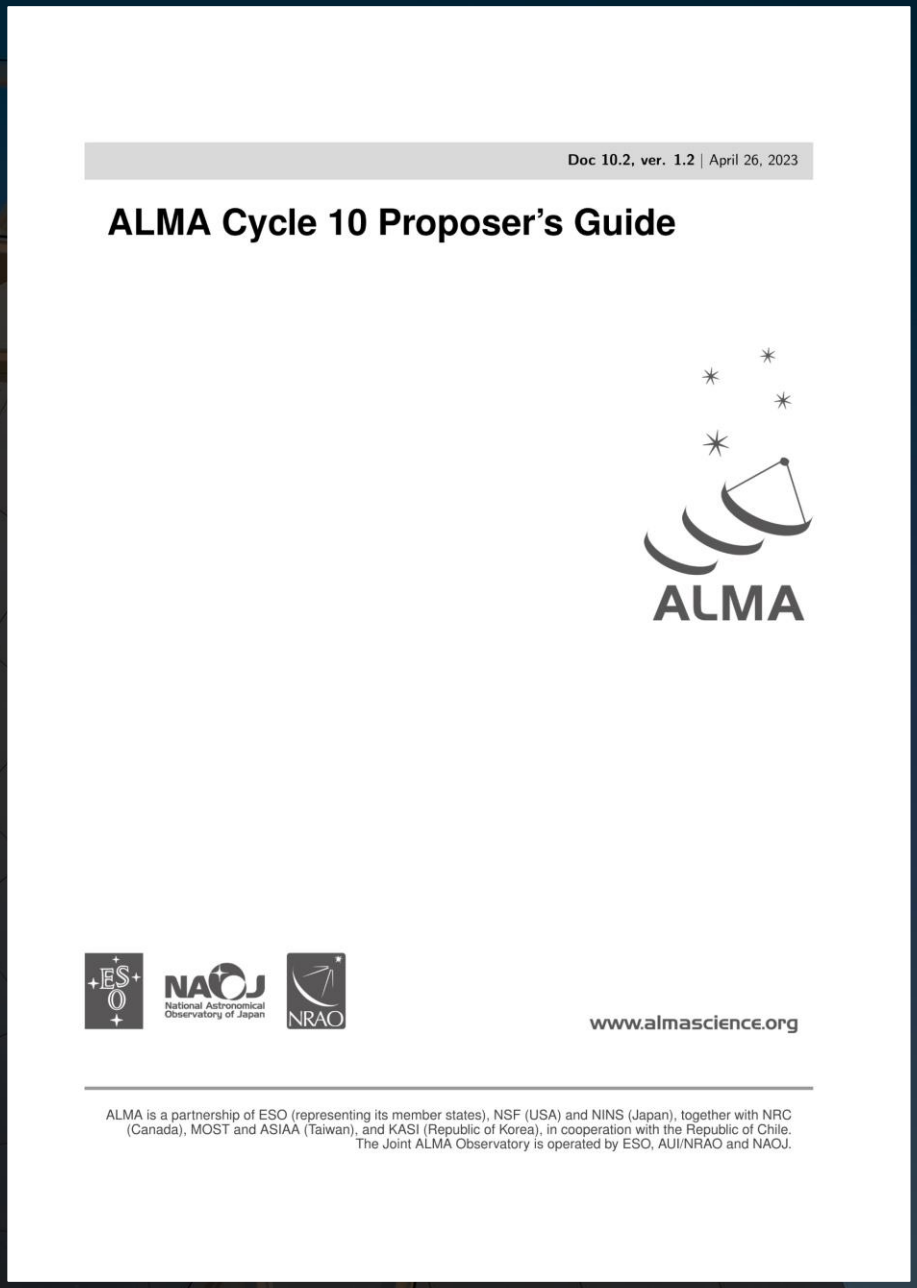
The documentation website (https:// almascience.eso.org/documents-and-tools) has three documents that are very useful references:

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



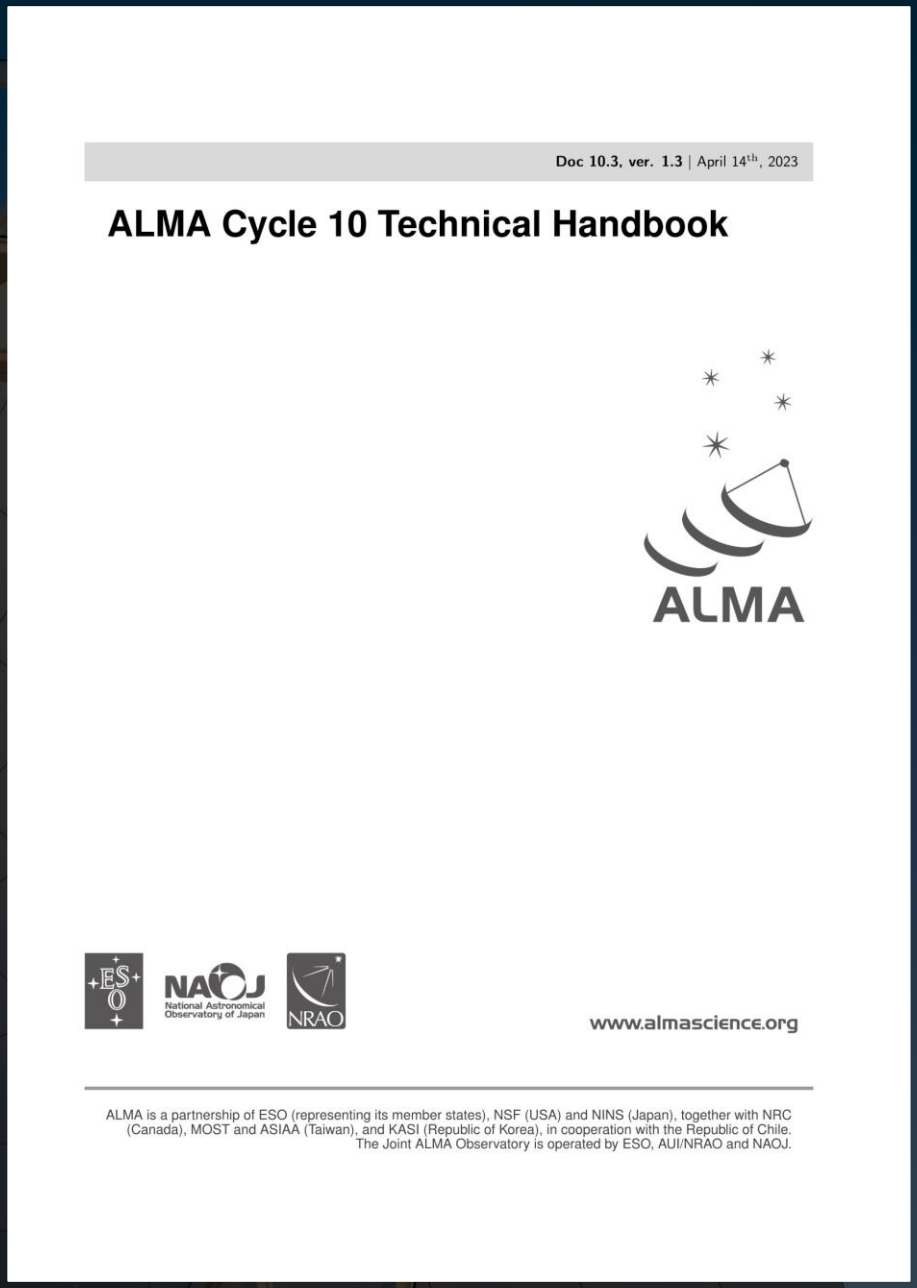
The documentation website (https:// almascience.eso.org/ documents-and-tools) has three documents that are very useful references:

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

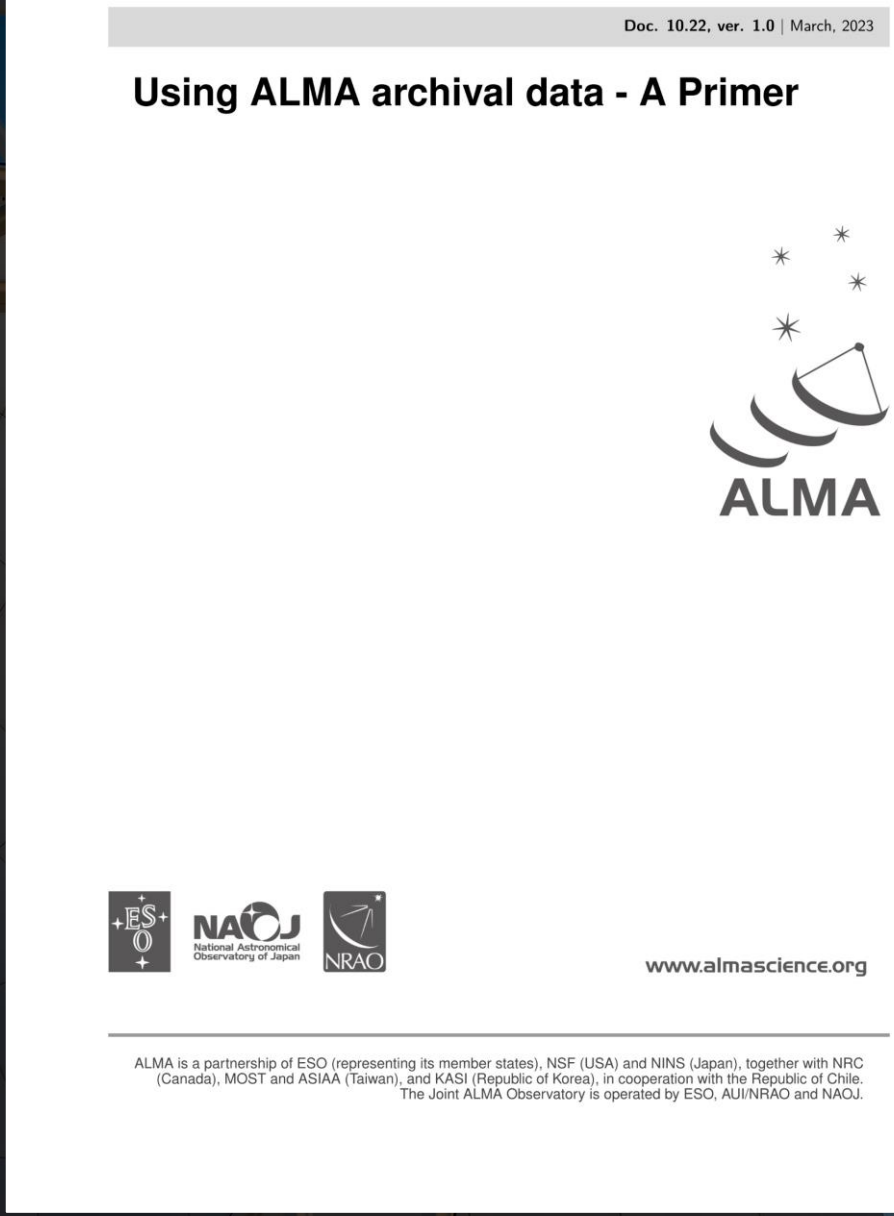


The documentation website (https:// almascience.eso.org/ documents-and-tools) has three documents that are very useful references:

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

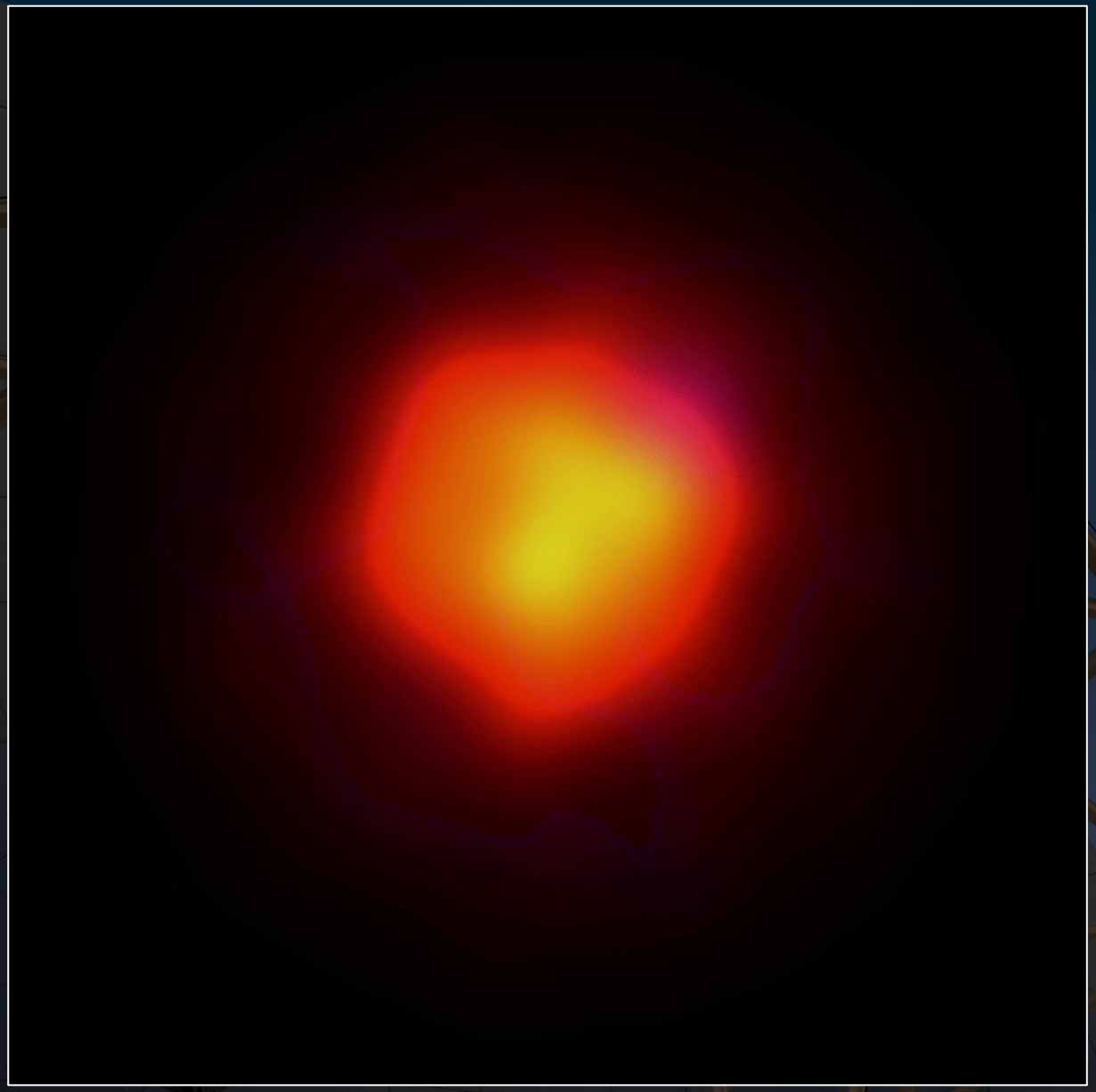


I have also worked on a document on using the ALMA Archive that is also available from https://almascience.eso.org/documents-and-tools.

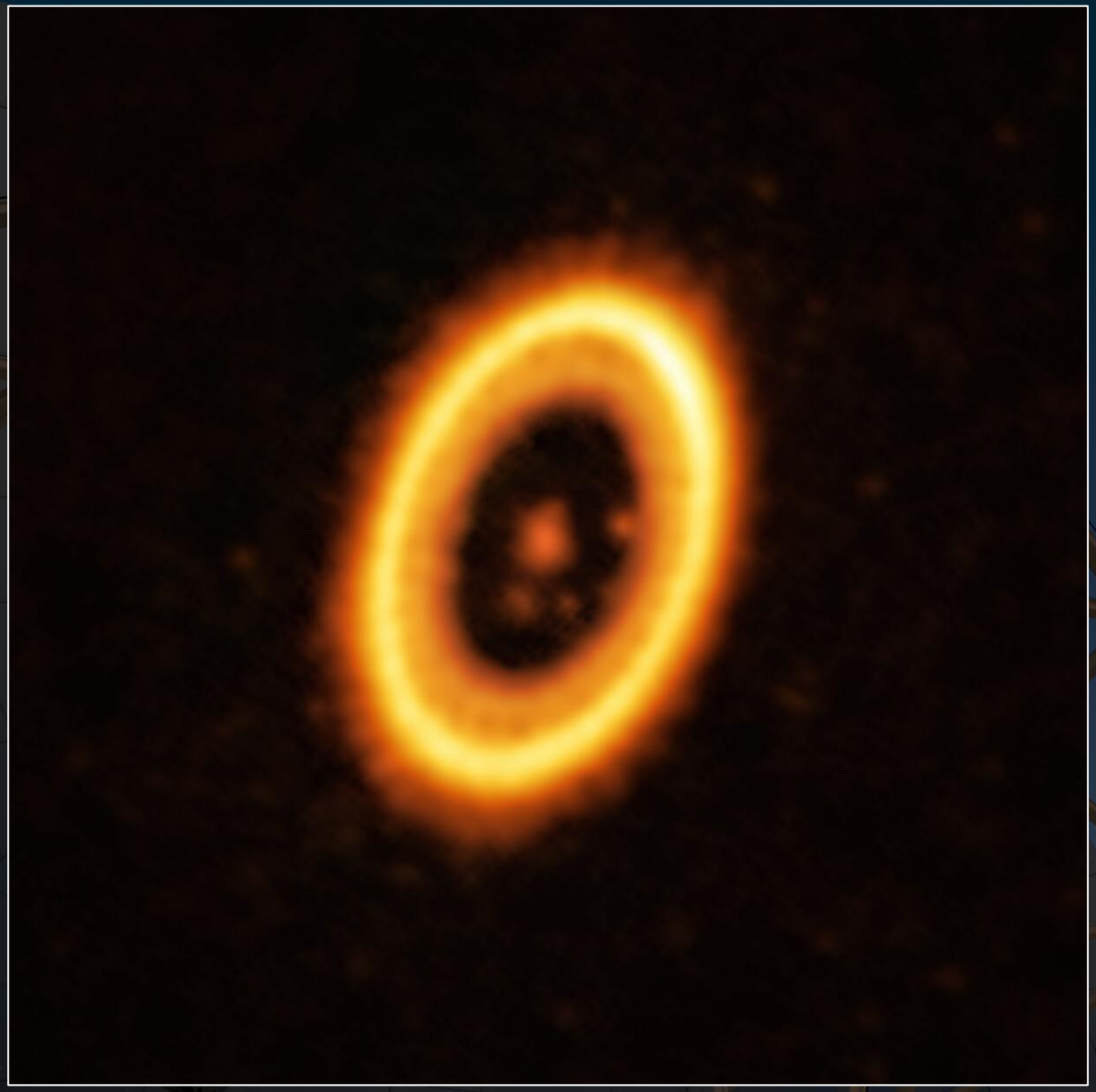


Cycle 11 schedule

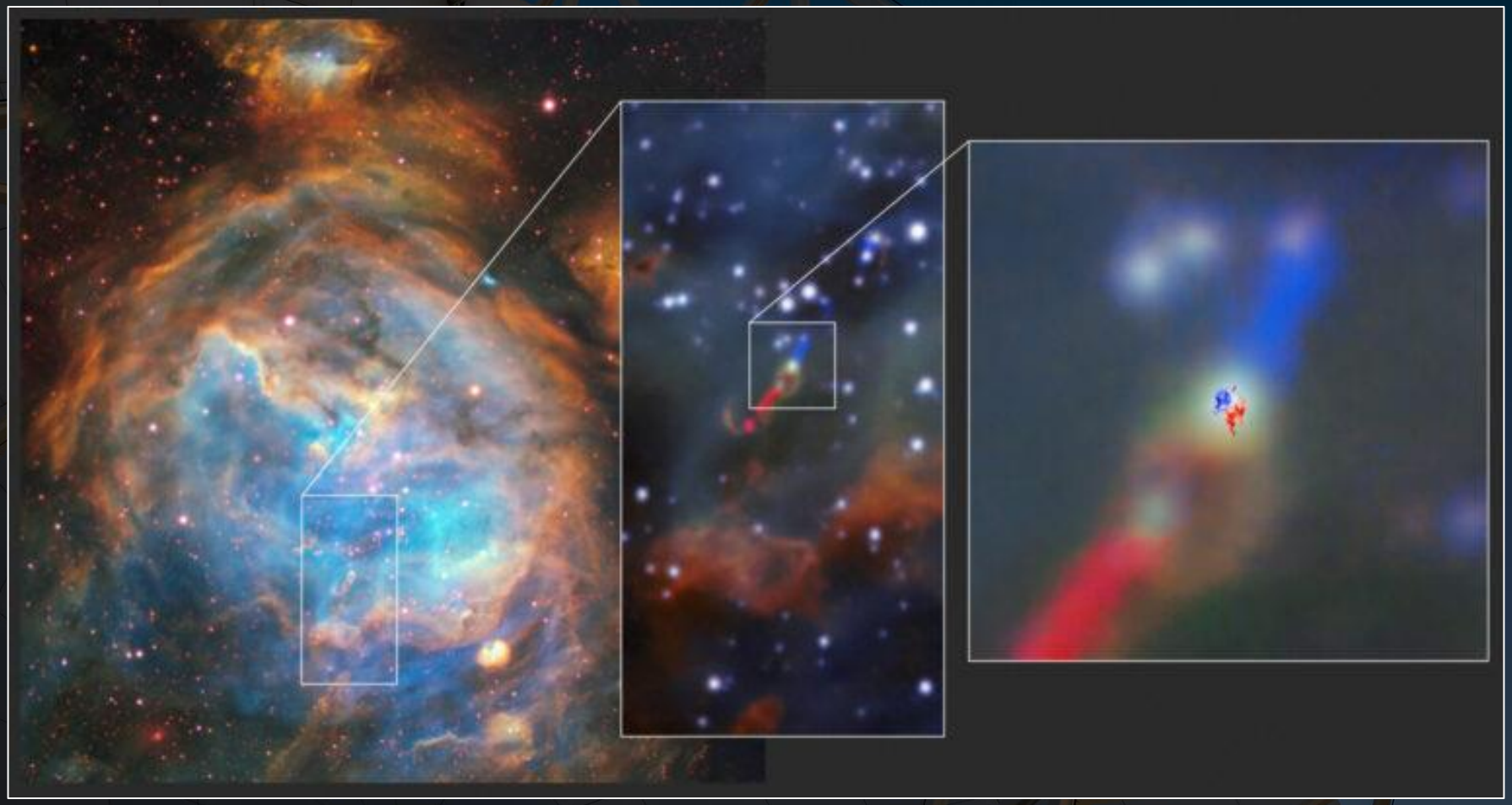
21 March 2024	Call for proposals
25 April	Proposals due
May-June	Distributed peer review process
mid-August	Grades for proposals are announced
September	Phase 2 of proposal submission (review of the Scheduling Blocks)
30 September	End of Cycle 10 observations
01 October	Start of observations for Cycle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



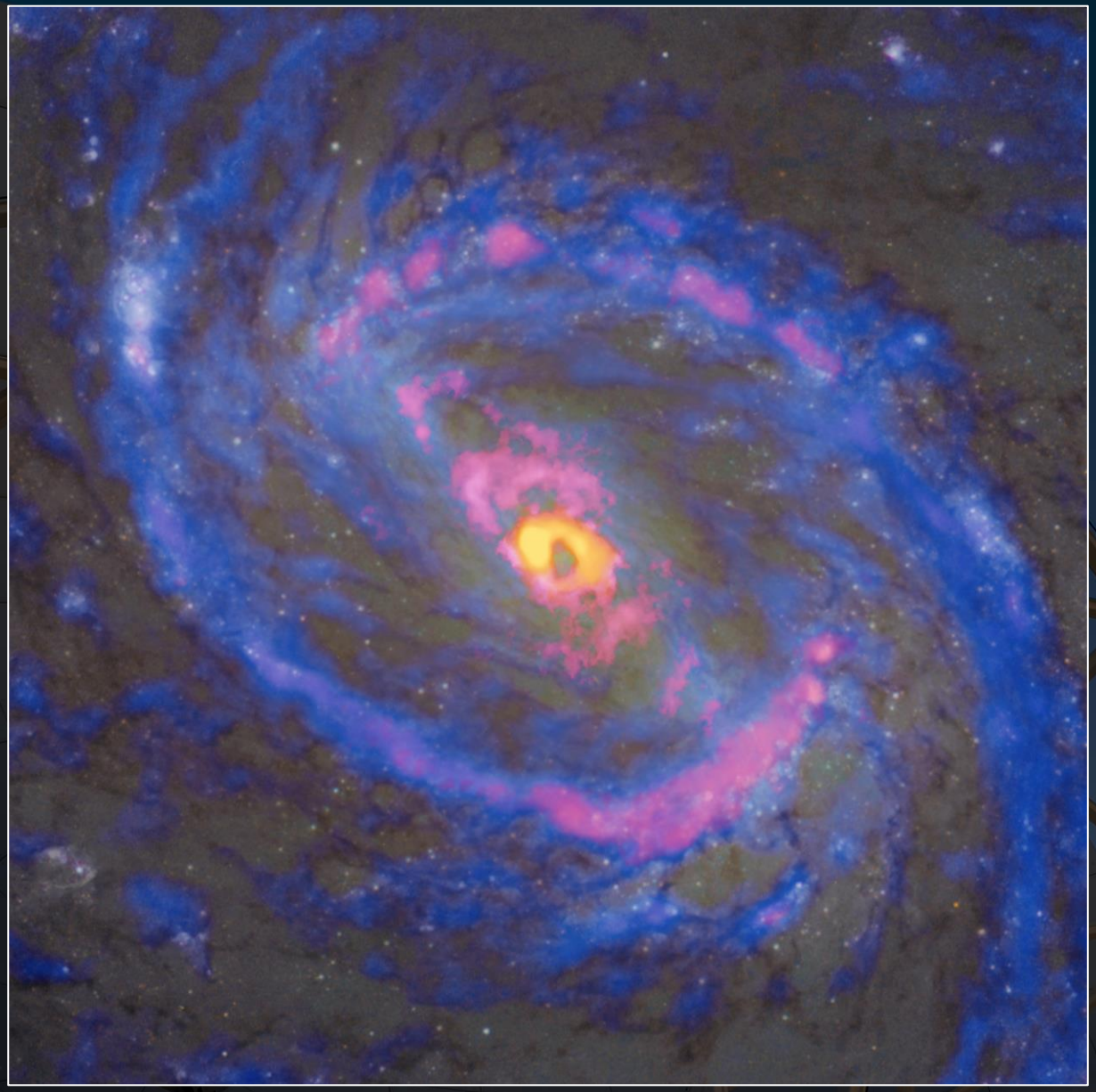
(Credit: Y. Asaki & N. Lira – ALMA (ESO/NAOJ/NRAO)



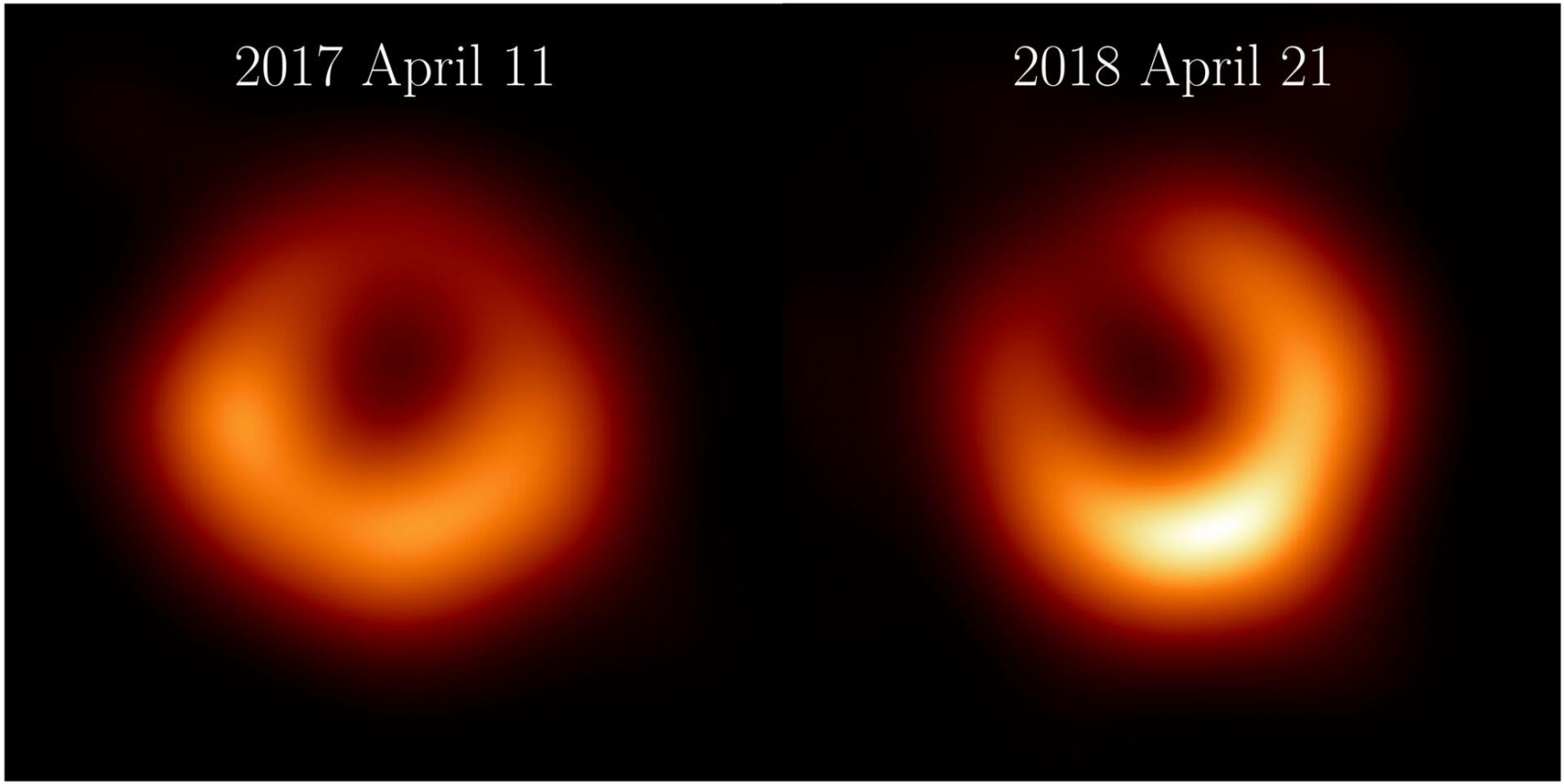
(Credit: ALMA (ESO/NAOJ/NRAO) / Balsalobre-Ruza et al.)



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

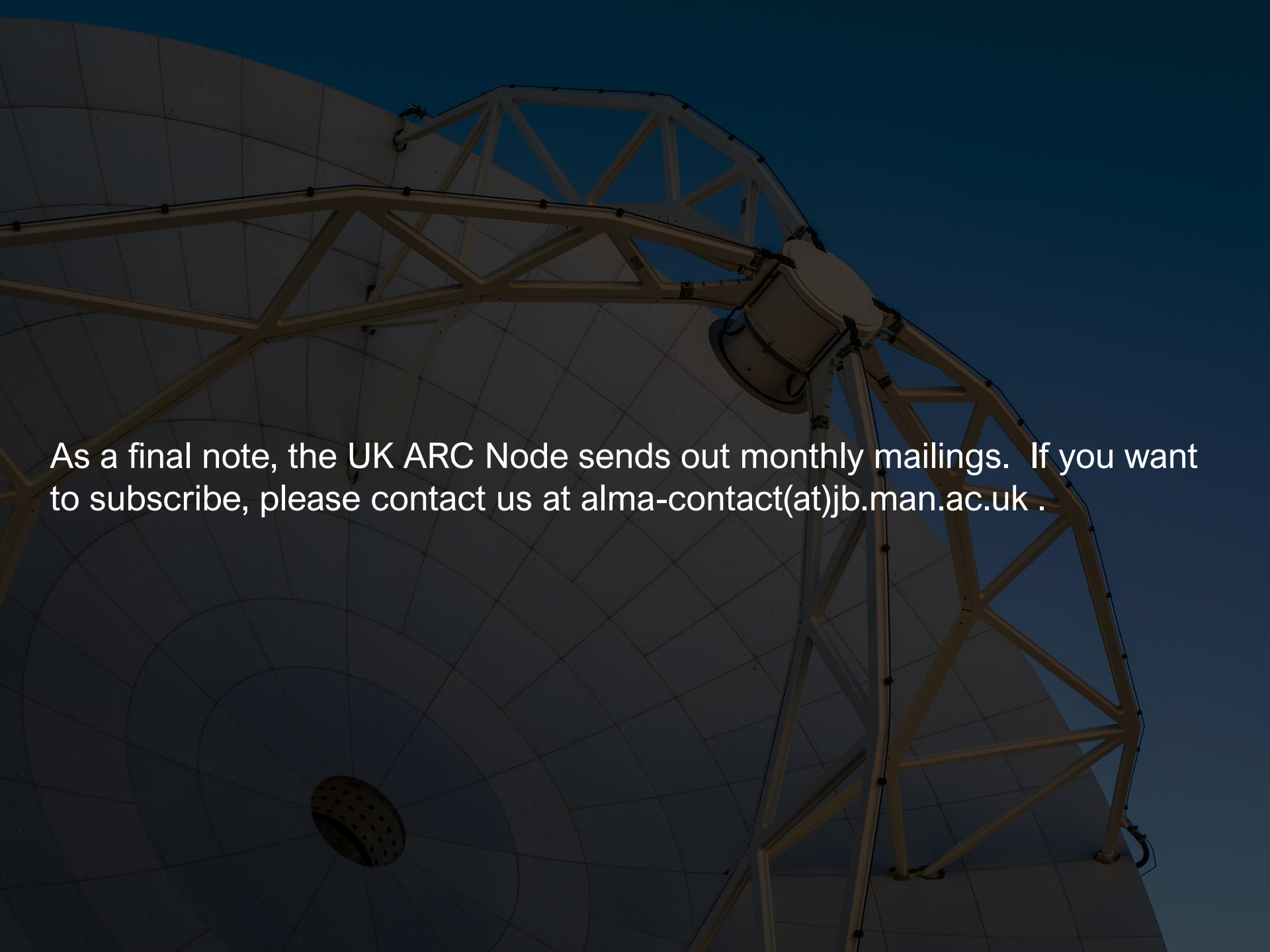


(Credit: ALMA (ESO/NAOJ/NRAO), NASA/ESA Hubble Space Telescope, T. Nakajima et al.)



(Credit: EHT Collaboration)

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



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