



SPANISH
ALMA Days

18-20 February 2025, La Laguna, Tenerife, Spain

AN INTRODUCTION TO ALMA

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Photos: EH, 2014

WHAT IS ALMA?

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ALMA is the most powerful astronomical radio observatory in the history of mankind

ALMA is capable of observing like never before a part of the Universe that remained unexplored



Credit: ALMA (ESO/NAOJ/NRAO), J.F. Salgado

A gigantic collaboration between Europe (ESO), North America, East Asia and Chile, unique in the history of science

THE HISTORY OF ALMA

In the 80s and 90s three independent ideas for an interferometer in the Southern Hemisphere emerged:

- Europe (IRAM, ESO, OSO, NFRA): Large Southern Array (LSA)
- USA (NRAO): Millimeter Array – MMA
- Japan (NAOJ): Large Southern Millimetre Array (LSMA)

Quickly recognised that joining forces to build one instrument would benefit all parties

... and that's how ALMA was born

First project meeting between USA and Europe on 21 Feb 1999 in Tucson (USA)

Late 2008 the first 12m antenna, built by Mitsubishi Electric Corporation for NAOJ, was handed over to the observatory

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Llano de Chajnantor 2006



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ALMA was inaugurated in 2013, last antenna delivered, end of construction



The final ALMA antenna

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

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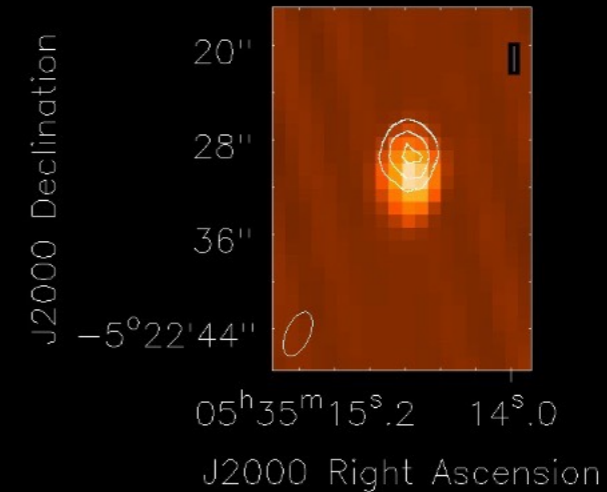
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First ALMA 'image' with three antennas, SiO and continuum emission of OMC-1, March 2010

Credit: ARC & JAO staff



First ALMA image, Antennae Galaxies (NGC 4038 and 4039), October 2011

Credit: ALMA (ESO/NAOJ/NRAO). Visible light image: the NASA/ESA Hubble Space Telescope

ALMA: A TRUELY DISTRIBUTED PROJECT

- * ALMA Partners: Europe, North America, East Asia
- * Chile is the host country and Chilean astronomers have 10% of the observing time
- * More than 20 countries are involved in ALMA
- * Construction cost: US \$1600 millions



ALMA: A TRUELY DISTRIBUTED PROJECT



ALMA partners, sharing construction and operations costs: ESO, North America, East Asia

Chile: Contributing with world-class observations site

ALMA Regional Centres (ARCs): Interfaces to the community, members of the Integrated Teams (IXTs), Subsystem Scientists, Astronomers on Duty (AoDs), expertise at all levels

Joint ALMA Observatory (JAO): Day-to-day operations, AoDs and array operators, leading the IXTs

ALMA: A TRUELY DISTRIBUTED PROJECT



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Atacama alti-plano – an exceptional site

High altitude – 5000m – excellent sub-mm atmospheric transparency

Large, flat expanse, ideal for large-scale construction



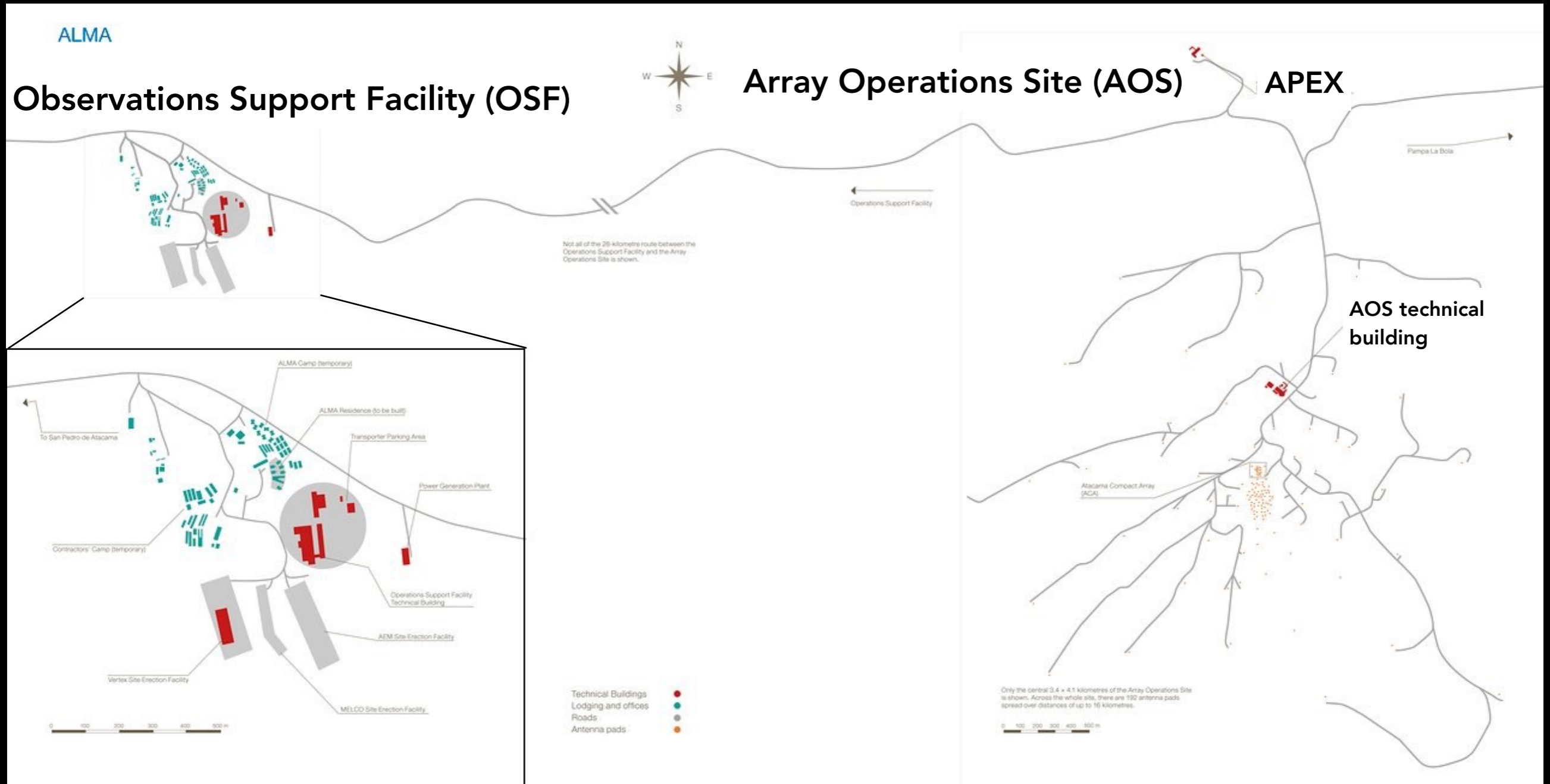
ALMA: A TRUELY DISTRIBUTED PROJECT

Operations Support Facility (OSF) at 3000m

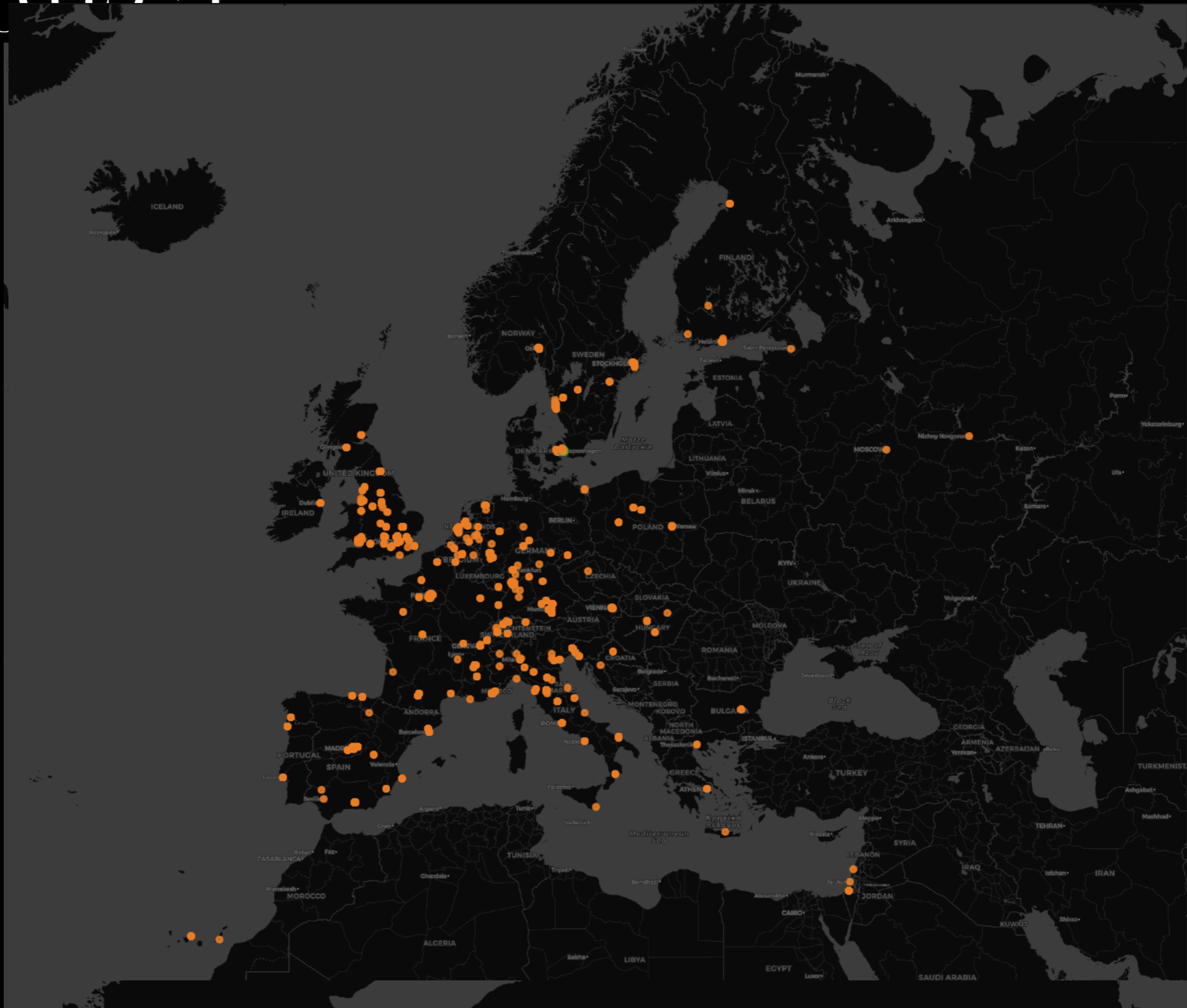


248 staff in total; 215 Chilean, 33 international
110-150 on-site for each shift

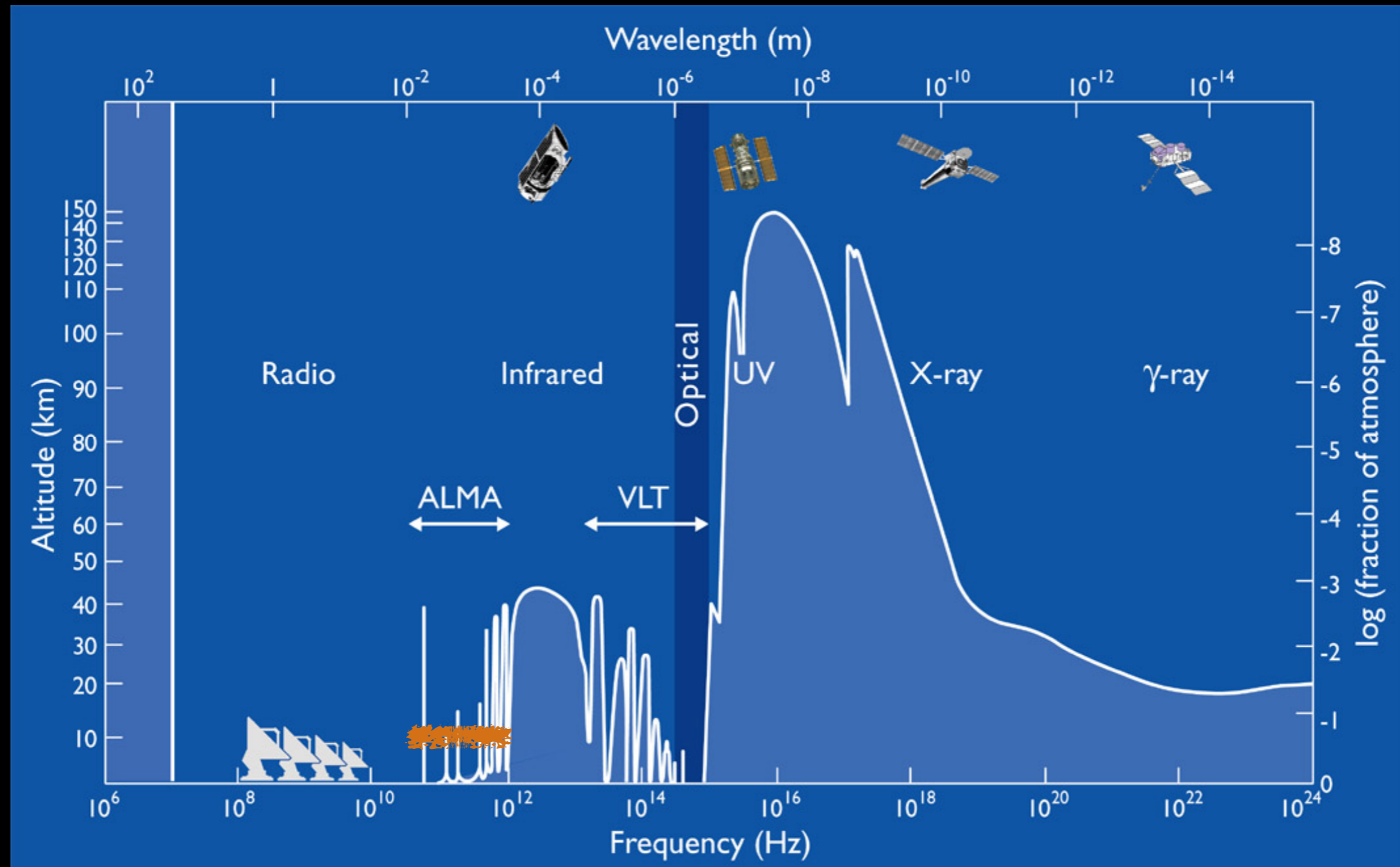
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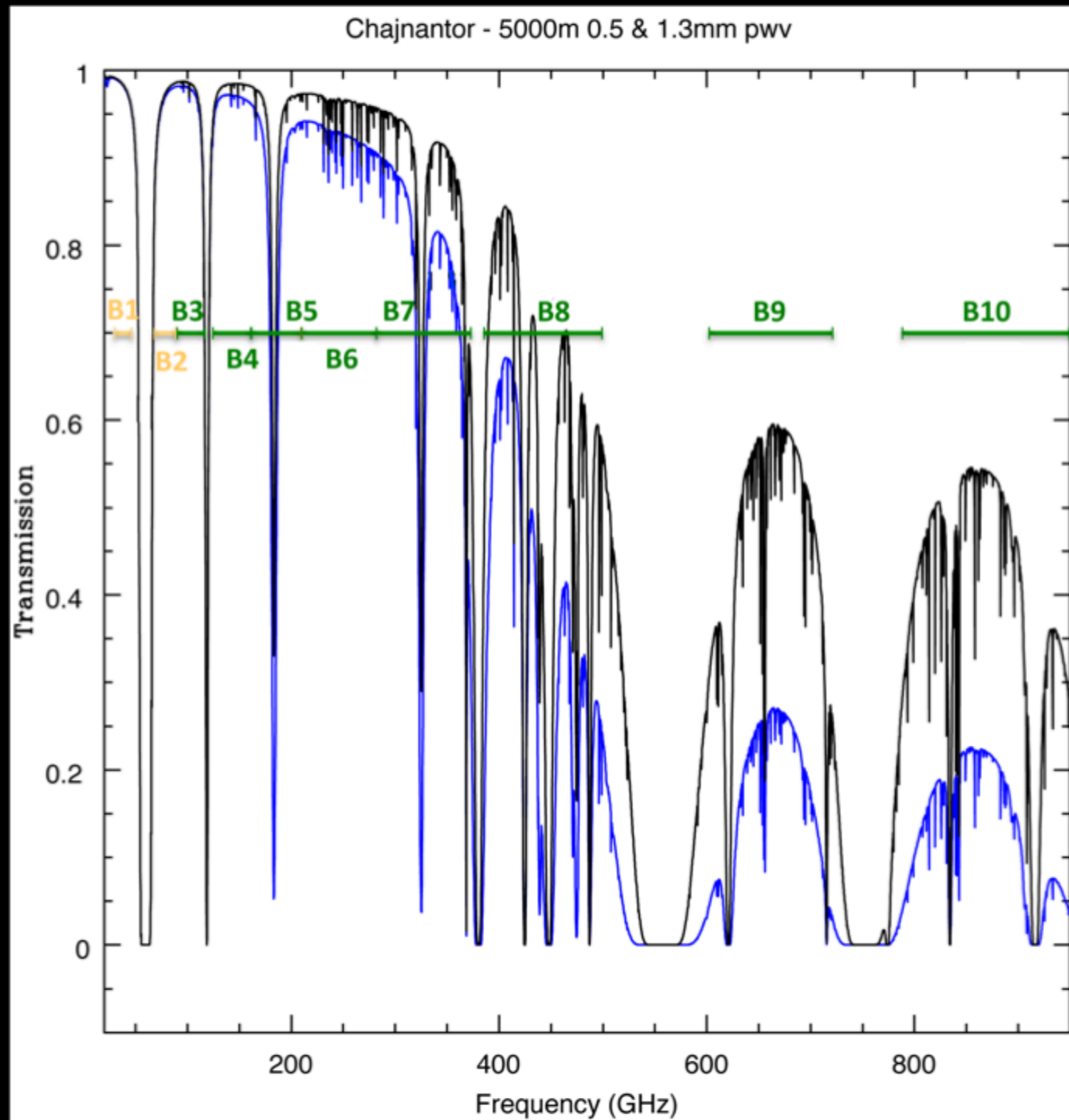


ALMA WAVELENGTHS



30–950 GHz = 10–0.3 mm

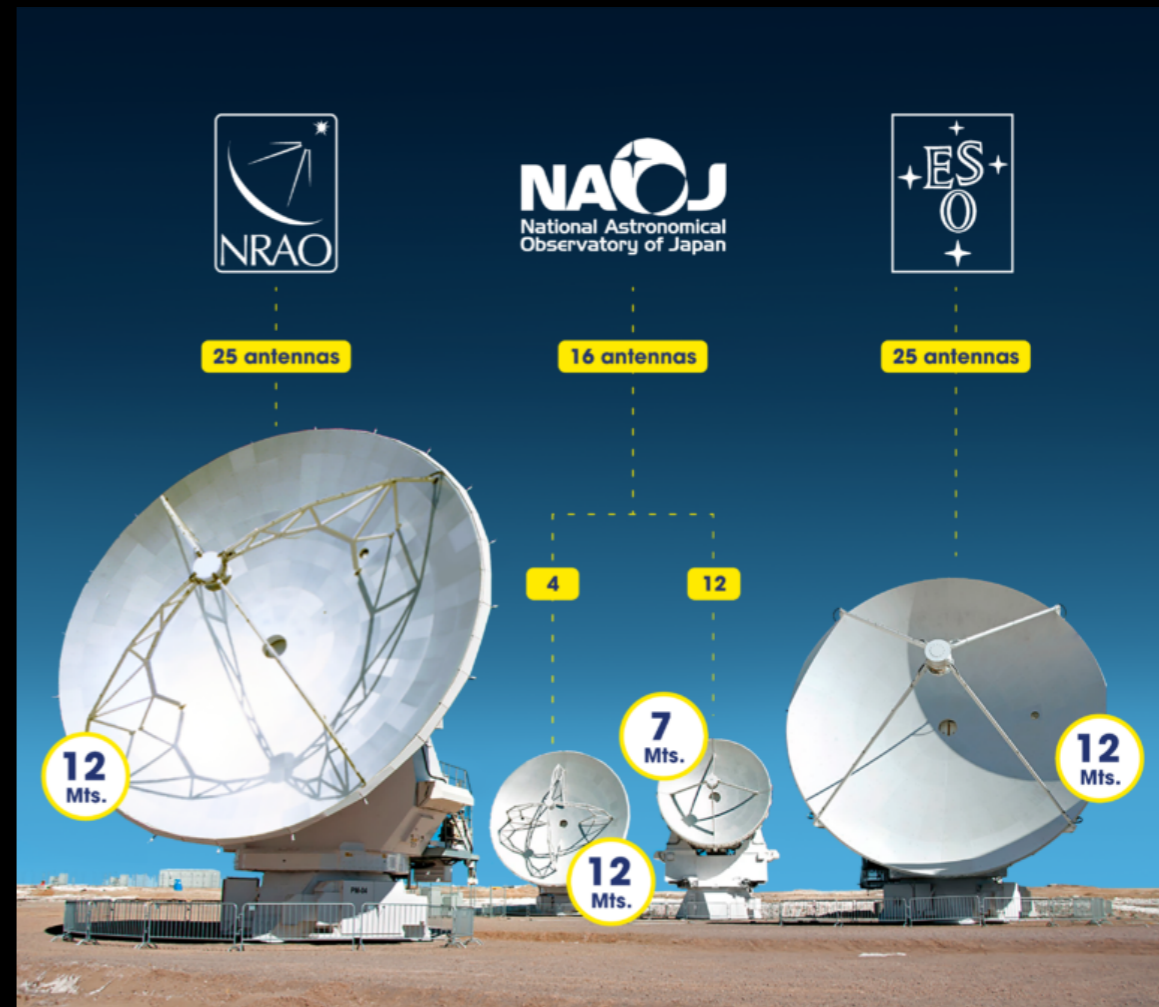
ALMA WAVELENGTHS



From the ALMA Primer

THE ALMA ANTENNAS

ALMA is composed of 66 antennas: 54 with a diameter of 12m and 12 with a diameter of 7m



Each antenna weighs 100 tons and most of them need to be moved regularly following a pre-established configuration schedule

THE ALMA ANTENNAS

Otto and Lore: 20 metres long, 10 metres wide and 6 metres high, each transporters weighs 130 tons (without cargo), and moves on 28 wheels. They can reach a maximum speed of 20 km/h, that is limited to 12 km/h when they carry an antenna



First European antenna handed over to the Joint ALMA Observatory (JAO)

Credit: ESO/S. Rossi

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Credit: ALMA (ESO/NAOJ/NRAO)



Credit: Denise Lira Rantinoff

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Credit: ALMA (ESO/NAOJ/NRAO)



Each antenna weighs 100 tons (100000 kilograms) and most of them need to be moved regularly and according to what we want to achieve with each observation

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THE ALMA ANTENNAS

Parabolic antennas

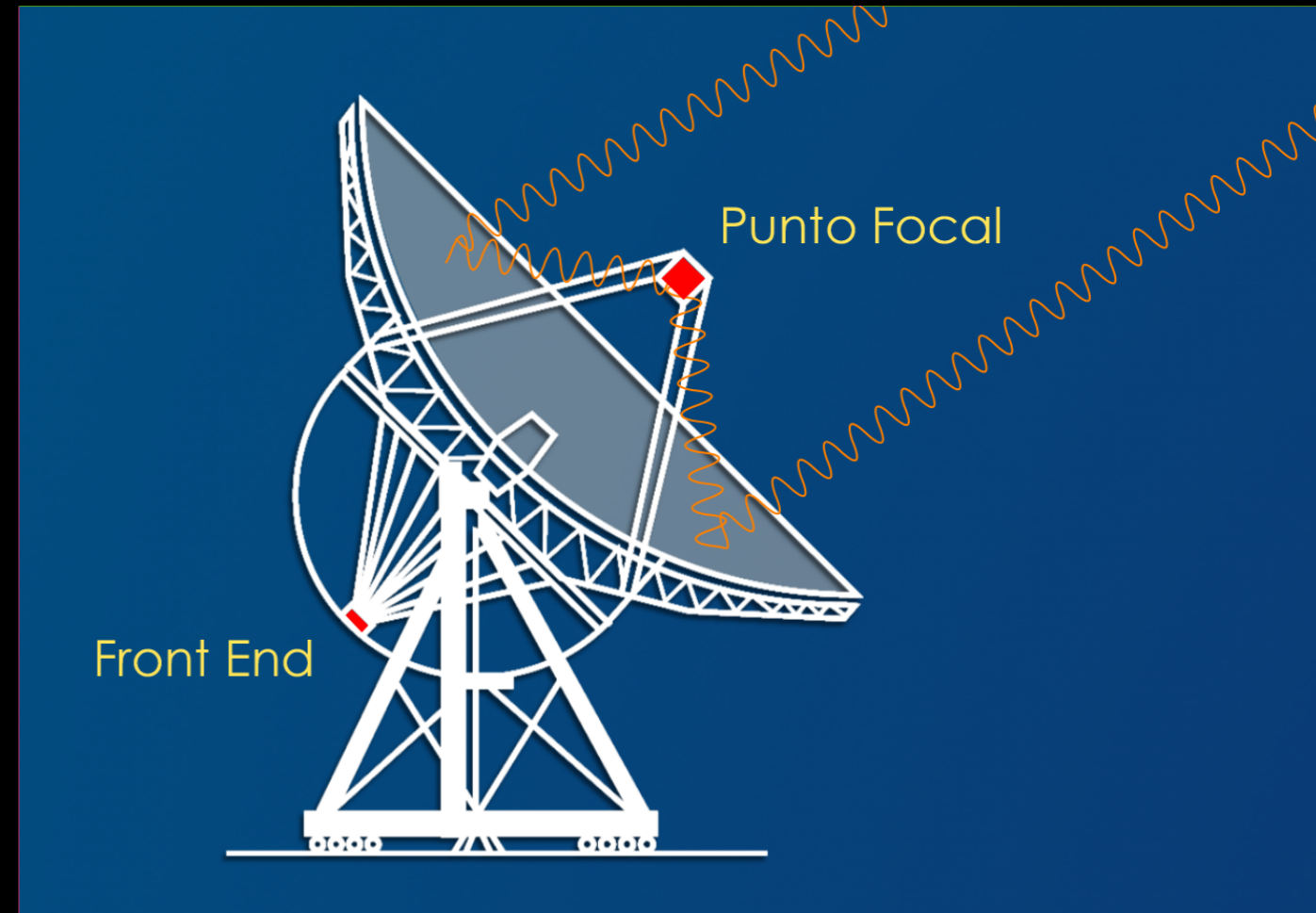


Credit: ALMA (ESO/NAOJ/NRAO)

THE ALMA ANTENNAS

Parabolic antennas

Permit to collect the signal that arrives at their surface and concentrate it to a single point called “focal point”



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THE ALMA ANTENNAS

Parabolic antennas

Permit to collect the signal that arrives at their surface and concentrate it to a single point called “focal point”

The signal, concentrated at the focal point is channeled to the receptors (bands), situated at the back of the antennas, a point called “front end”, where the signal is amplified and digitised in order to be processed



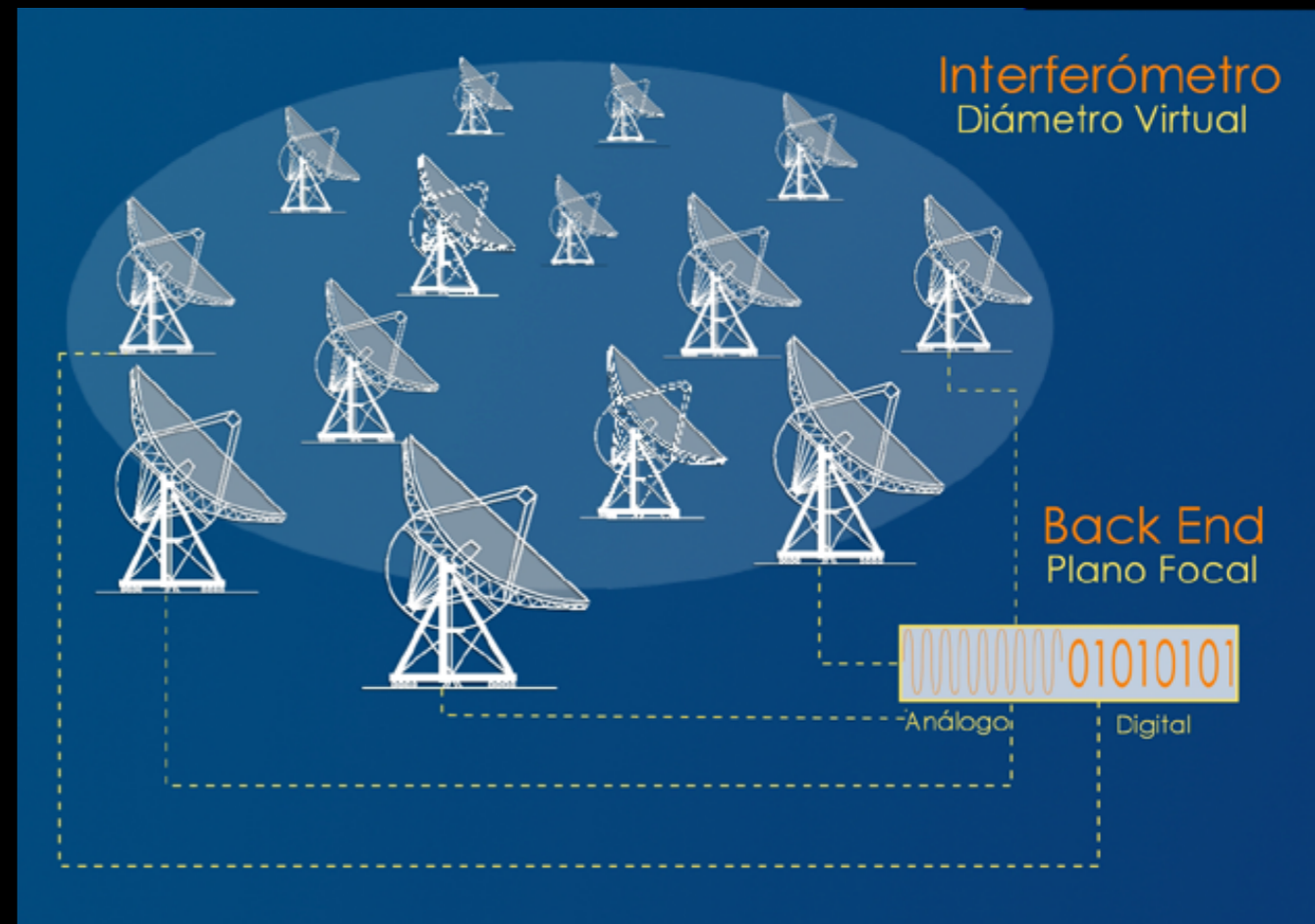
Credit: ALMA (ESO/NAOJ/NRAO)

INTERFEROMETRY

A measurement method using wave interference (light or radio waves).

With interferometry, radio signals from many antennas (or many telescopes) are combined to create an image that is much brighter and sharper than what is possible from a single antenna dish.

If the ensemble of antennas is synchronised to look at the same object and then the signals collected from each one of them are brought simultaneously to a focal plane, an image will be obtained, with a resolution equivalent to that obtained by one single antenna with a diameter equal to that of the array.



Interferometre

Credit: ALMA (ESO/NAOJ/NRAO)

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The 66 ALMA antennas form a radio interferometer with a maximum diameter of up to 16 km.



"Baile de antenas" (the dance of the antennas)

Credit: Ravi Deepres and Luke Unsworth (ravideepres.com)

THE CORRELATOR

The signal collected by the 66 antennas is processed by a very powerful computer called the 'correlator', with 134.000.000 processors capable to conduct 17.000.000.000.000.000 (!) operations per second



Photo: EH, 2014

HOW DO WE OBSERVE WITH ALMA?

The ALMA observing time is divided among ESO, North America, East Asia and Chile, in a way proportional to their respective contribution to the project. 5% of the total available time is open to astronomers that do not belong to any of these regions

The observations are run from the JAO in Santiago and the Operations Support Facility (OSF) located at an altitude of ~3000 metres



Operations Support Facility (OSF)

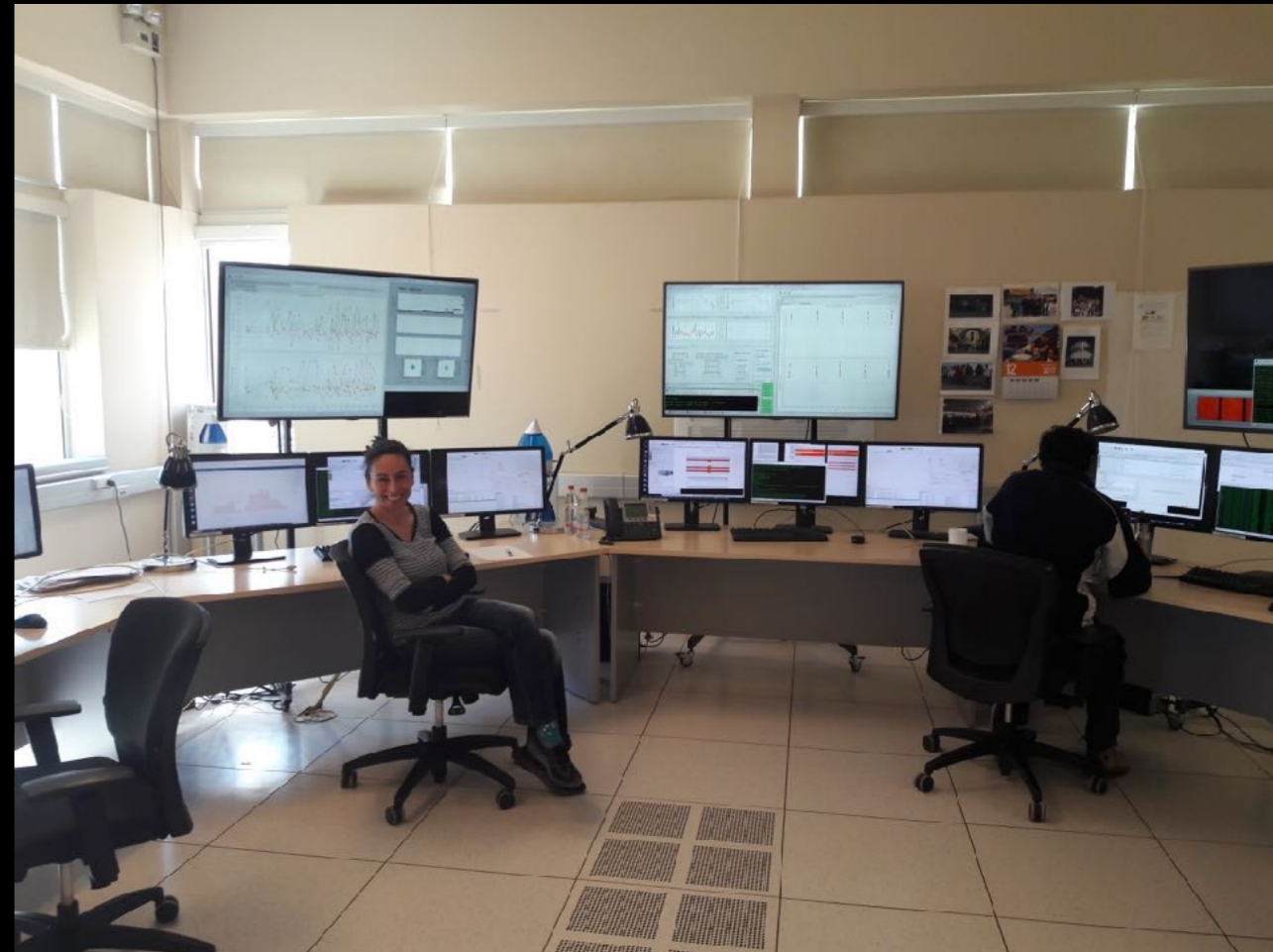
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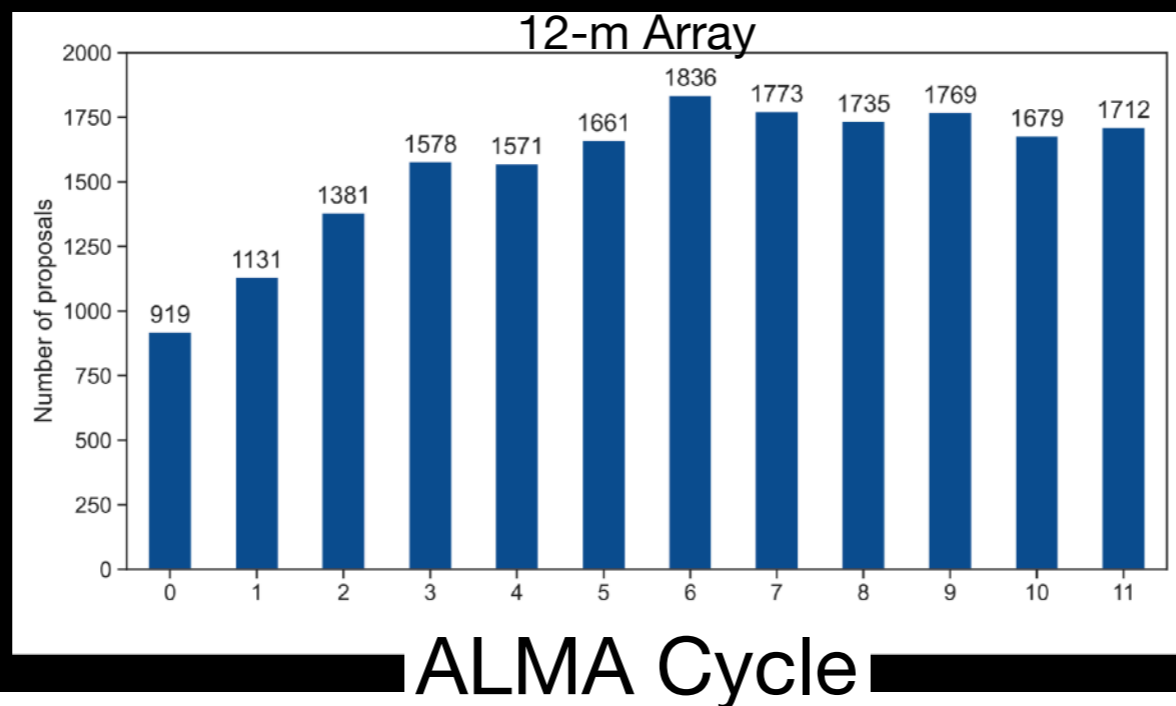
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ALMA does not operate in “visitor mode”. All observations are taken by trained ALMA staff from the JAO and the ARCs

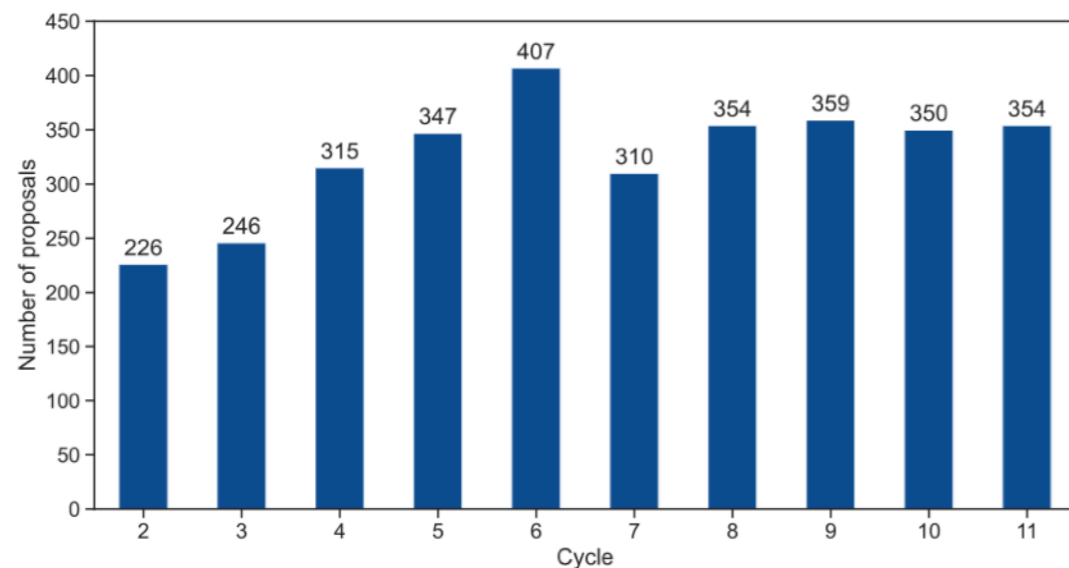


Control room at the Operations Support Facility (OSF)

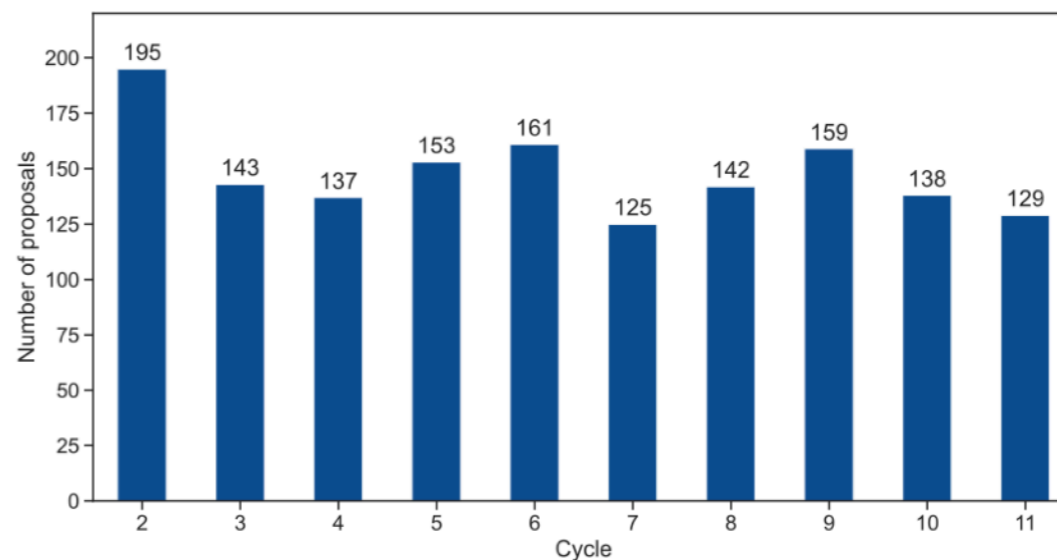
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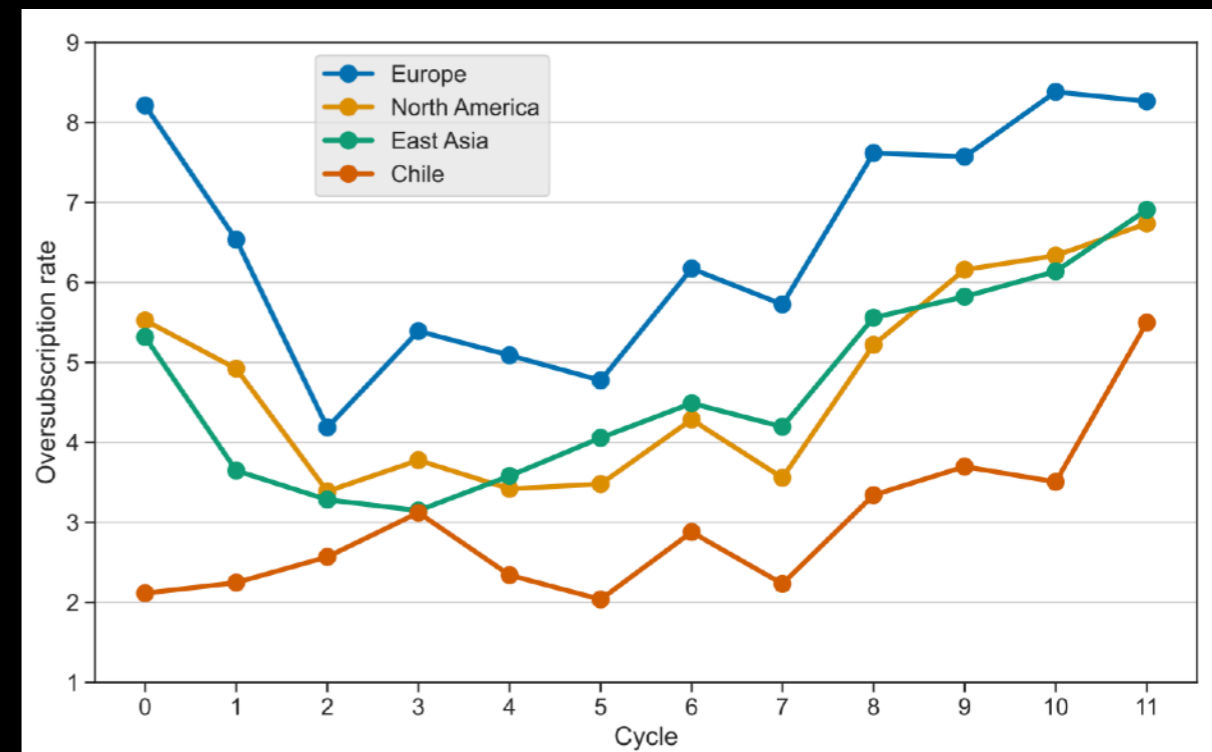
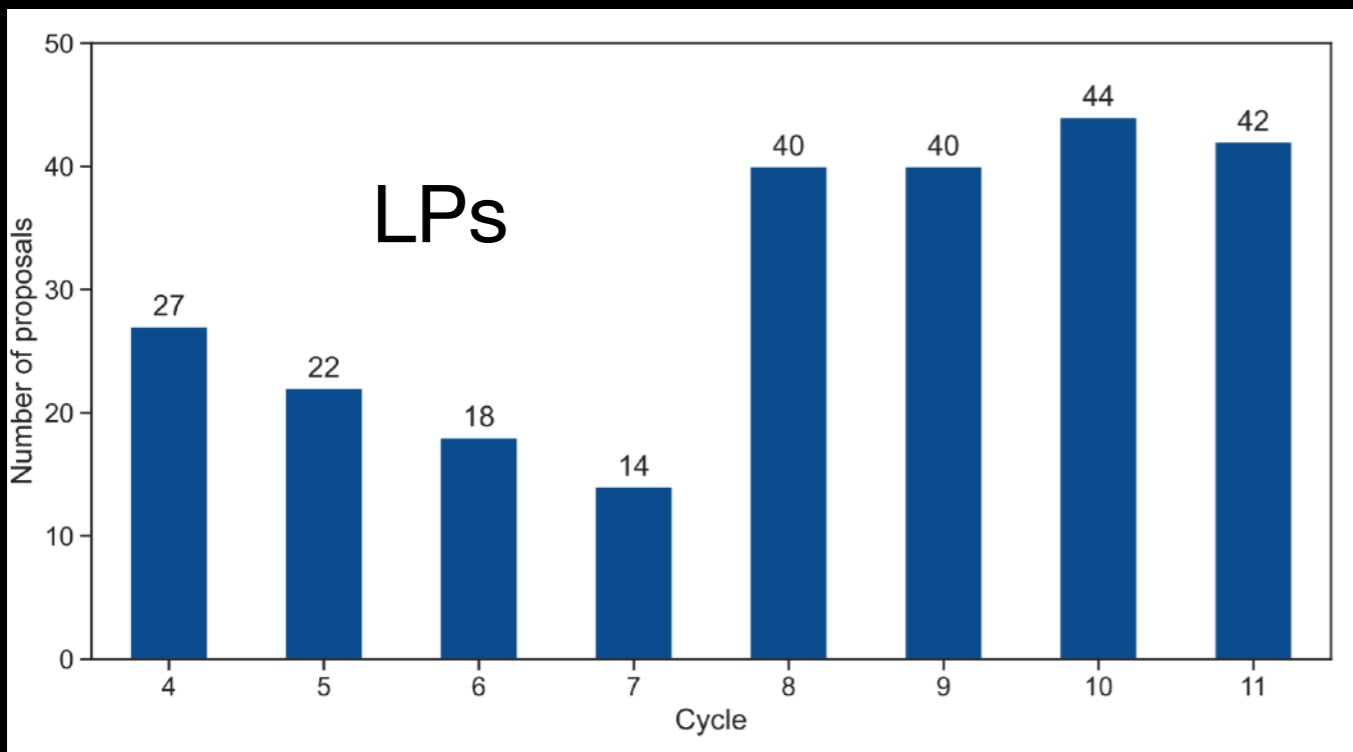
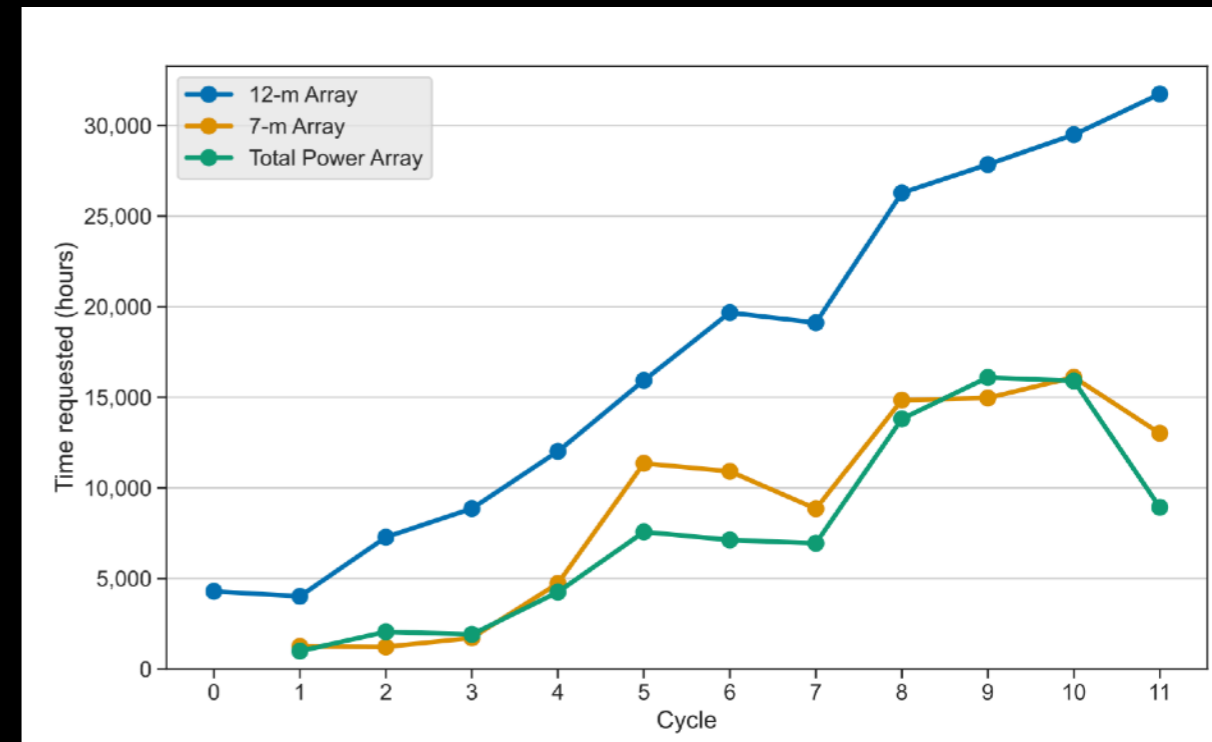
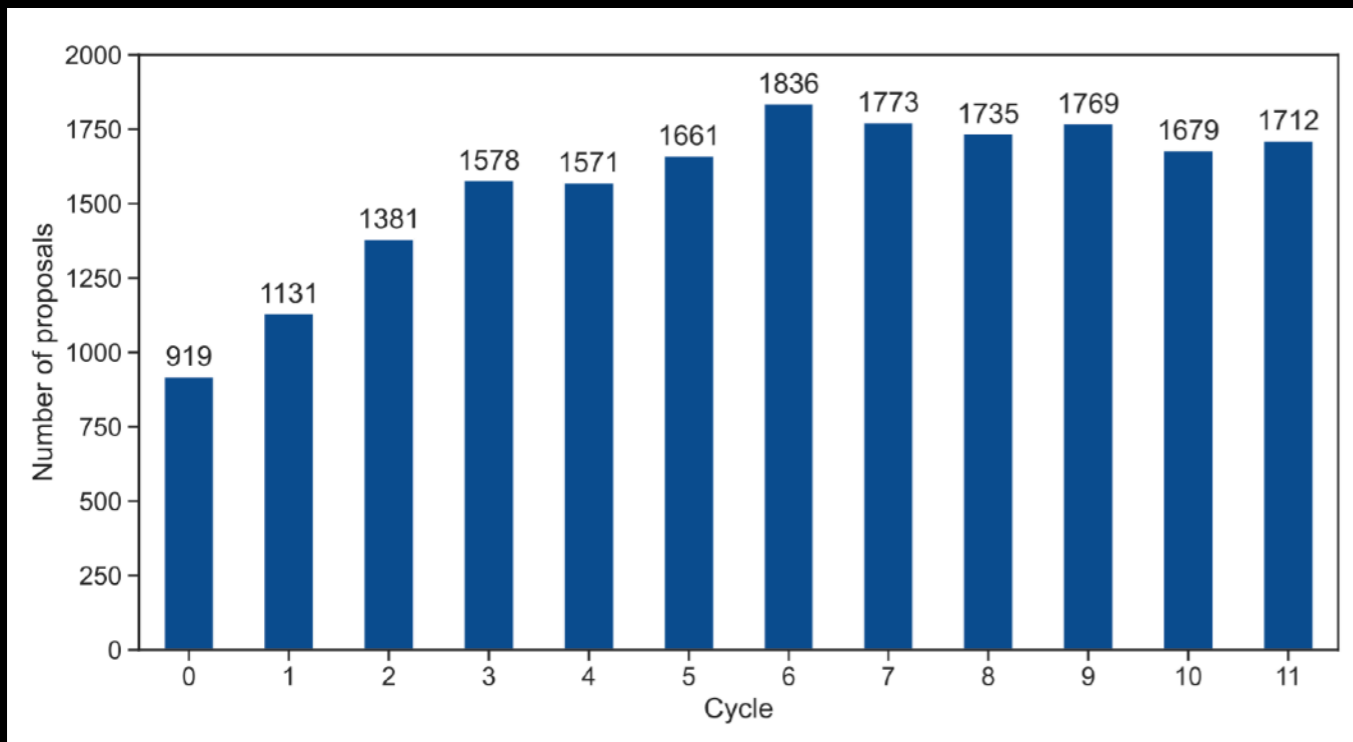
7-m Array



Total Power Array



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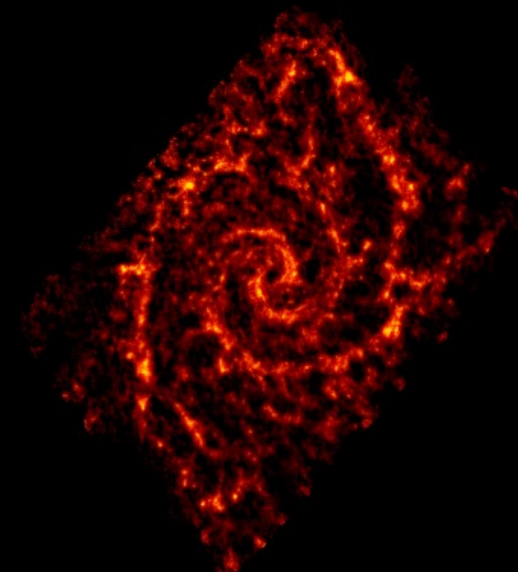
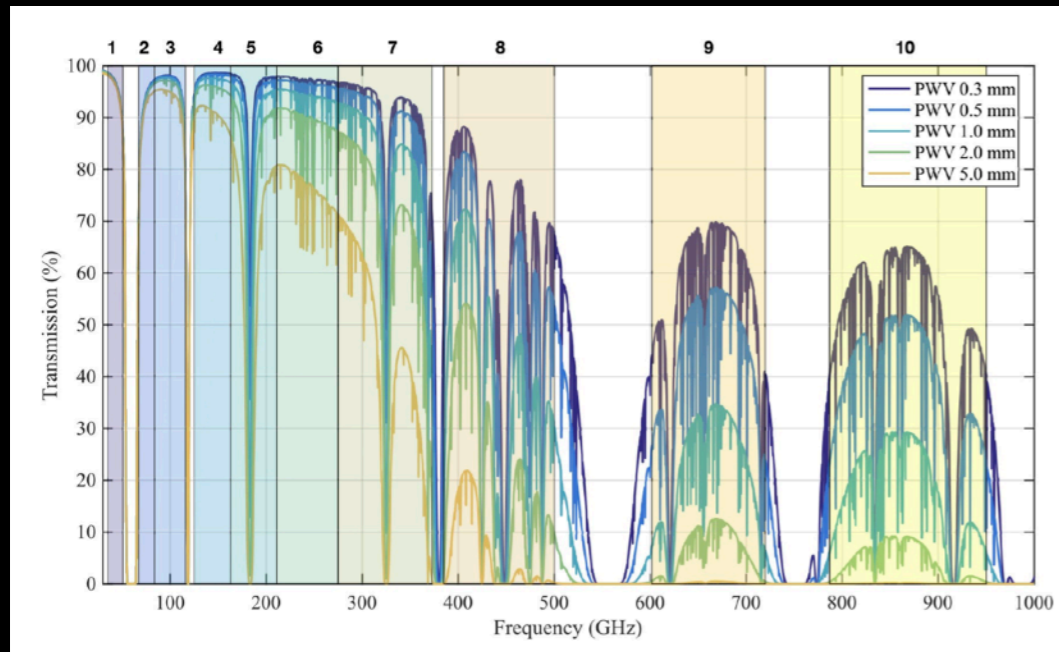


HOW DO WE OBSERVE WITH ALMA?

10 receiver bands
(35-950 GHz, $\lambda \approx 0.3 - 9$ mm)

Baselines: 0.16 to 16 km
(resolution as fine as 0.005" at 950 GHz)

Imaging

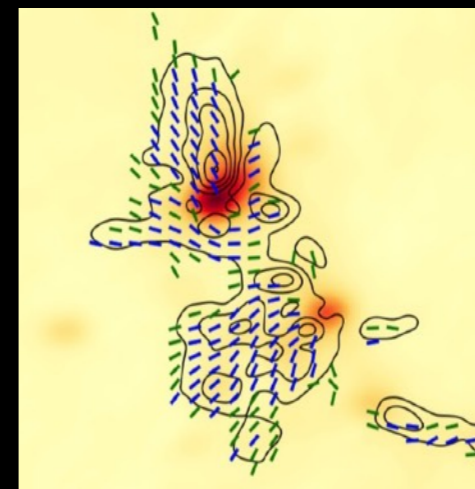
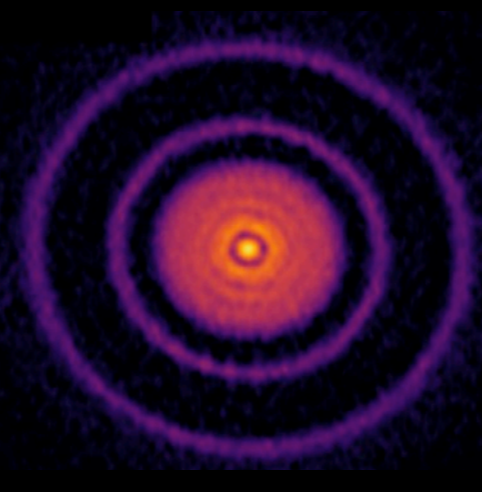
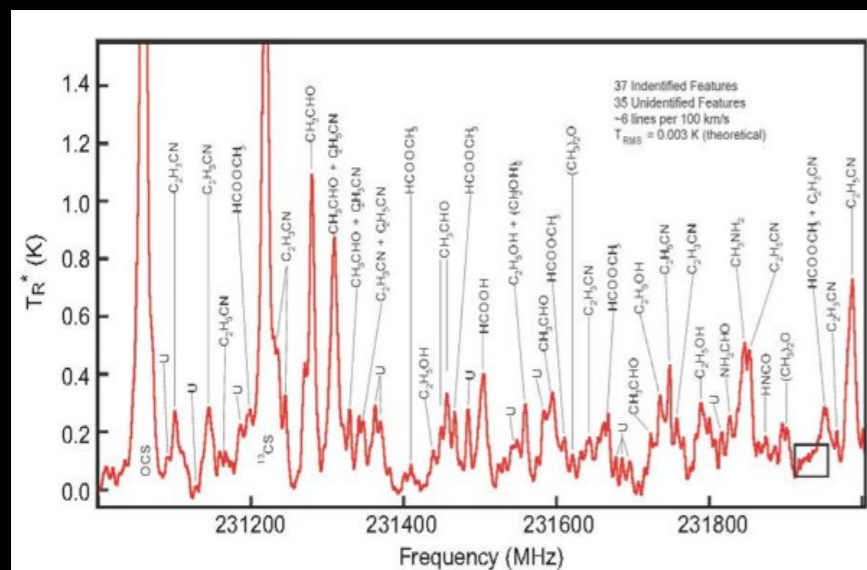


Spectroscopy

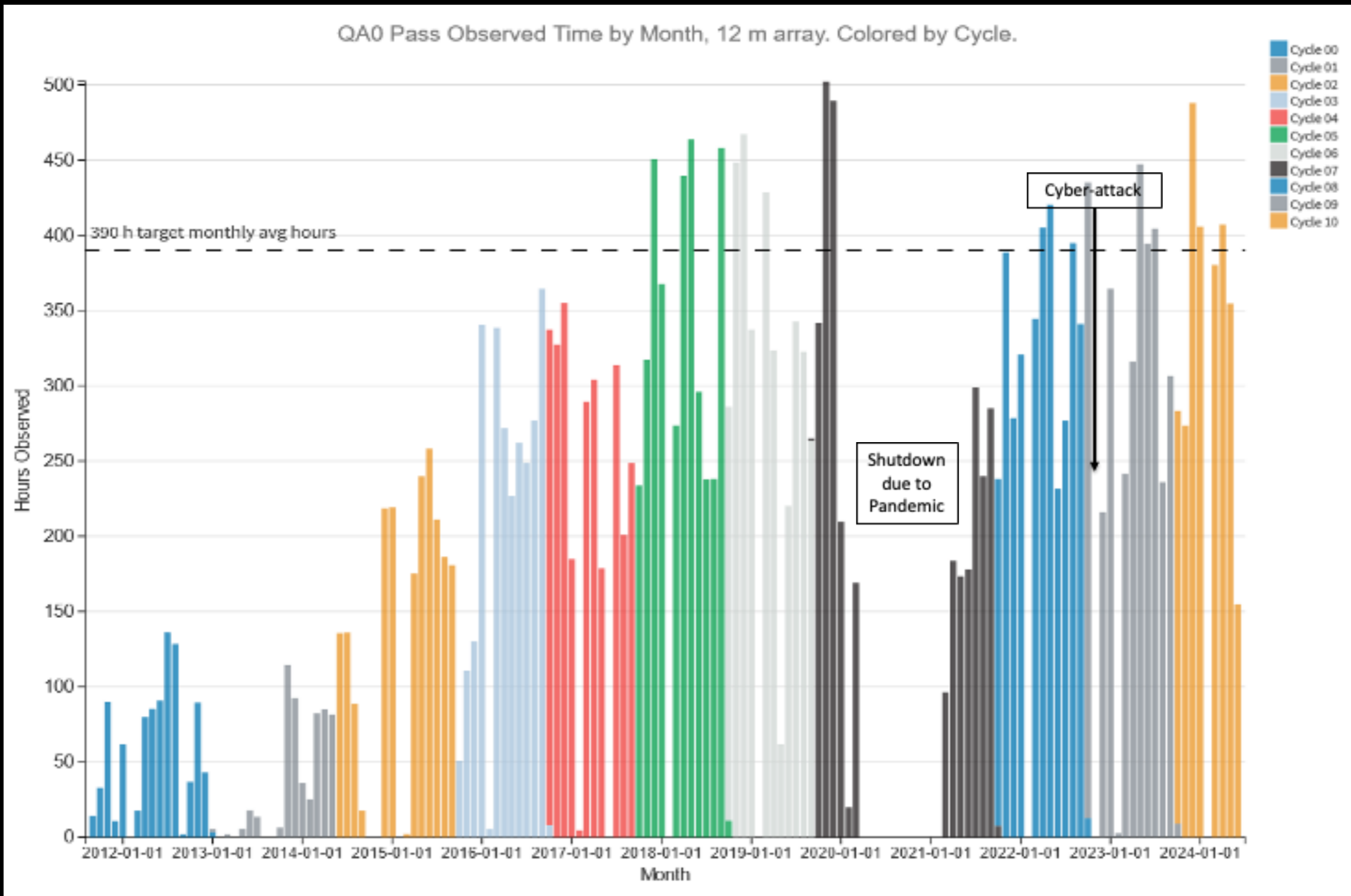
Continuum

Polarization

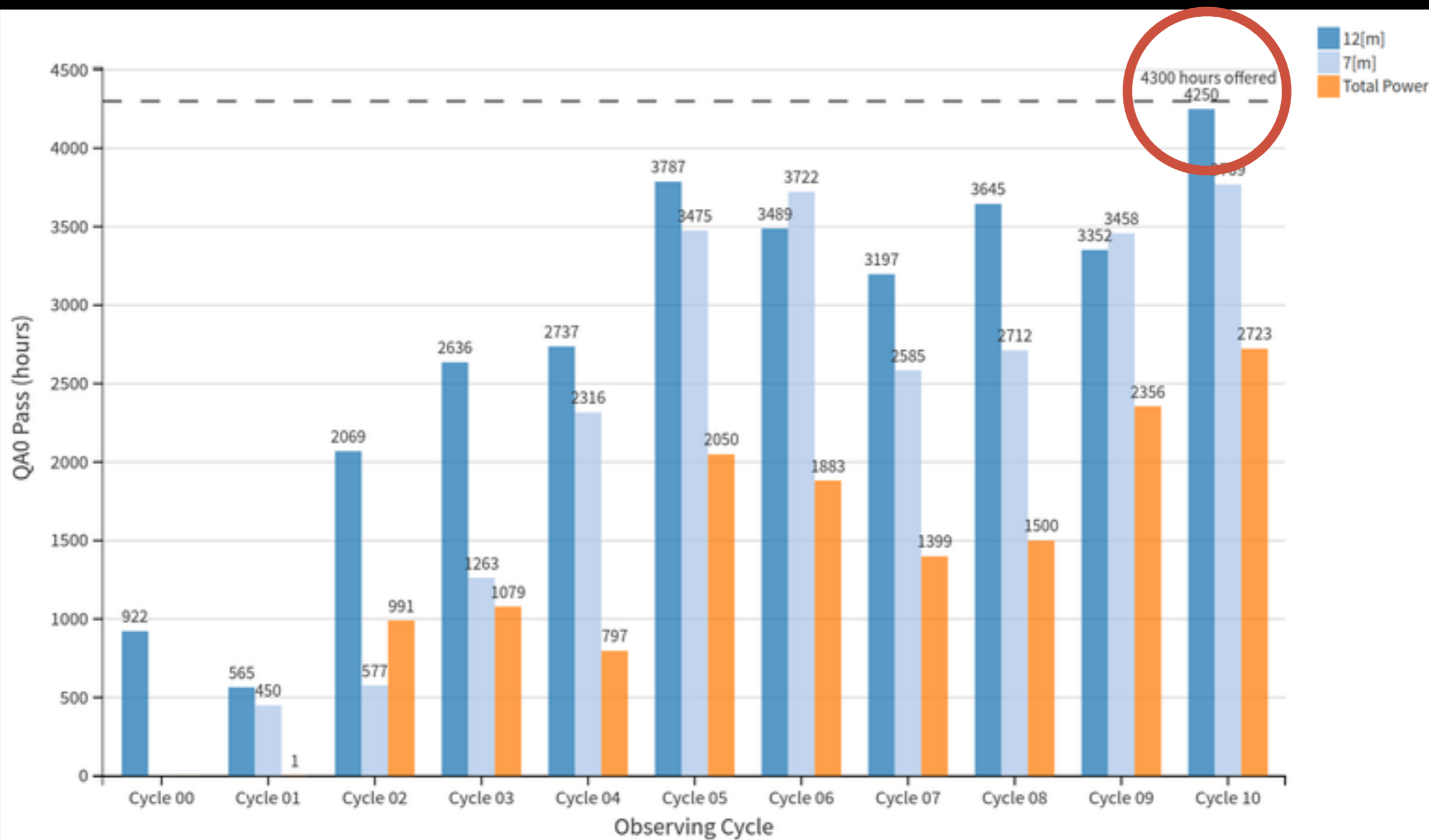
VLBI



HOW DO WE OBSERVE WITH ALMA?



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ALMA USER SUPPORT IN EUROPE

Seven nodes + ESO, 50+ experts, there to support >4000 registered ALMA users with European affiliations

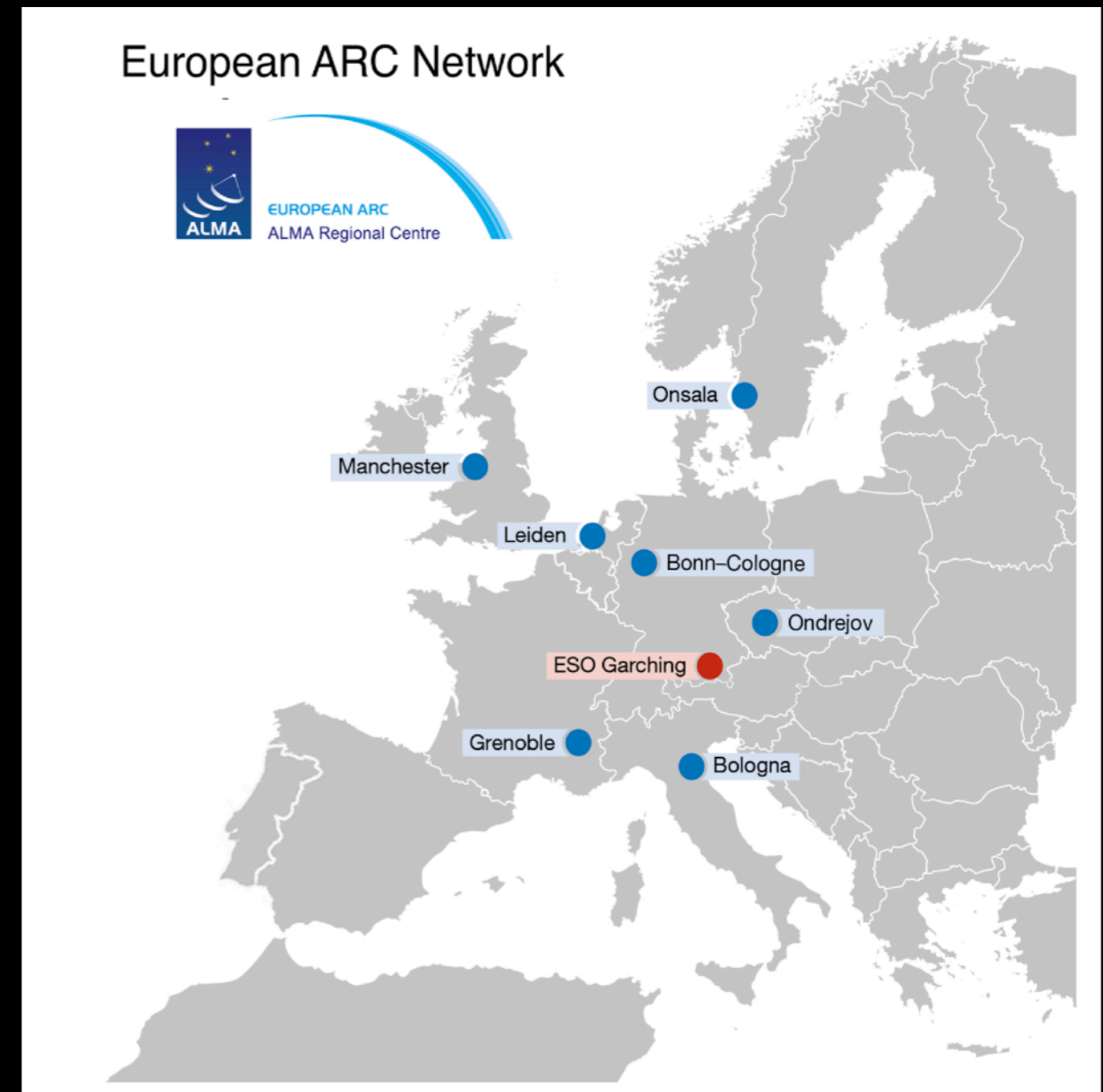
Support with:

- Proposal preparation
- Imaging
- Archival Research
- Face-to-face visit (ORP funding)

Community development:

- Community days
- Science and technical workshops
- Online tutorials (e.g. I-TRAIN)
- Videos

Presence in big science events and many more



10 + YEARS OF DISCOVERIES

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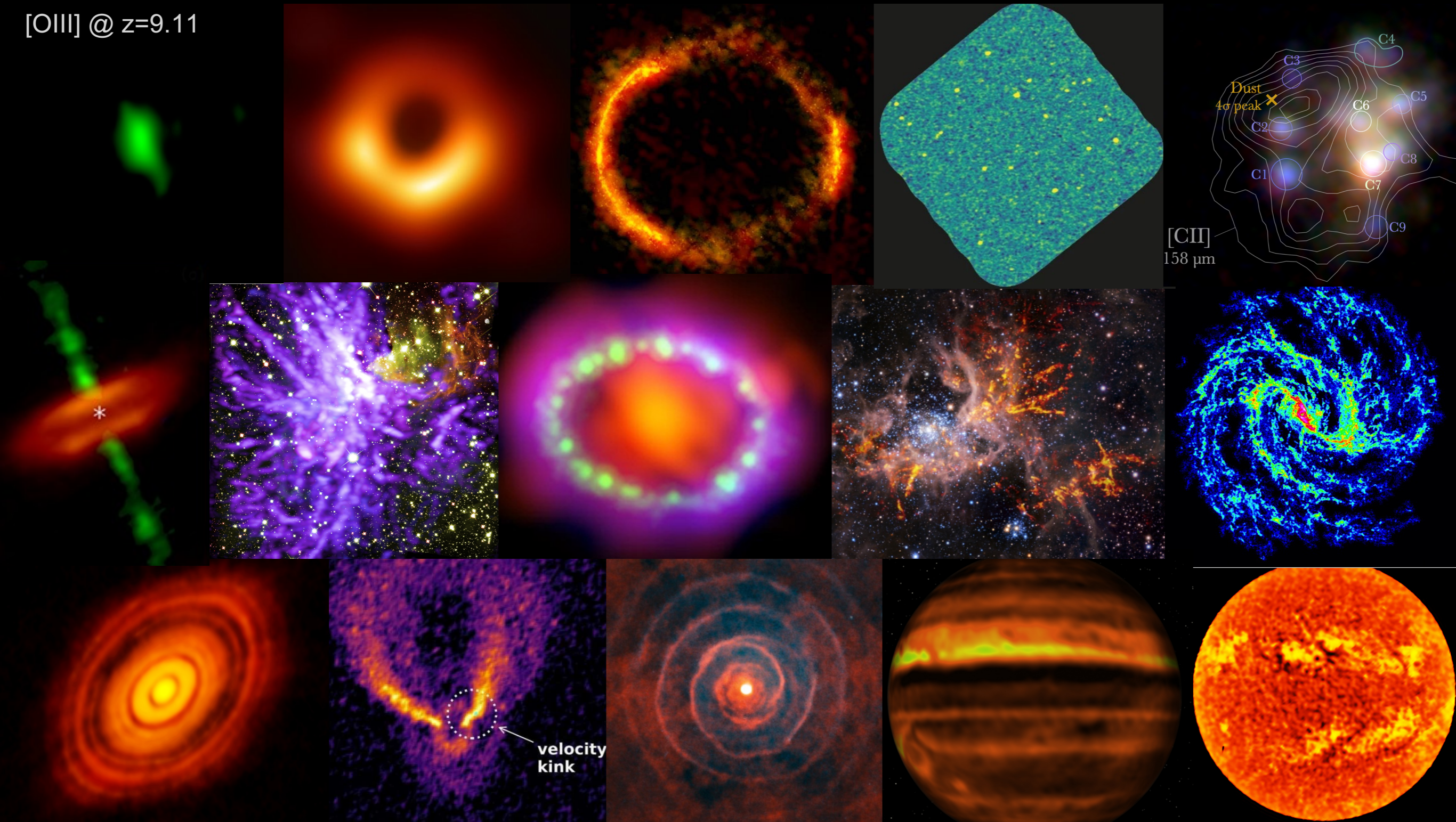


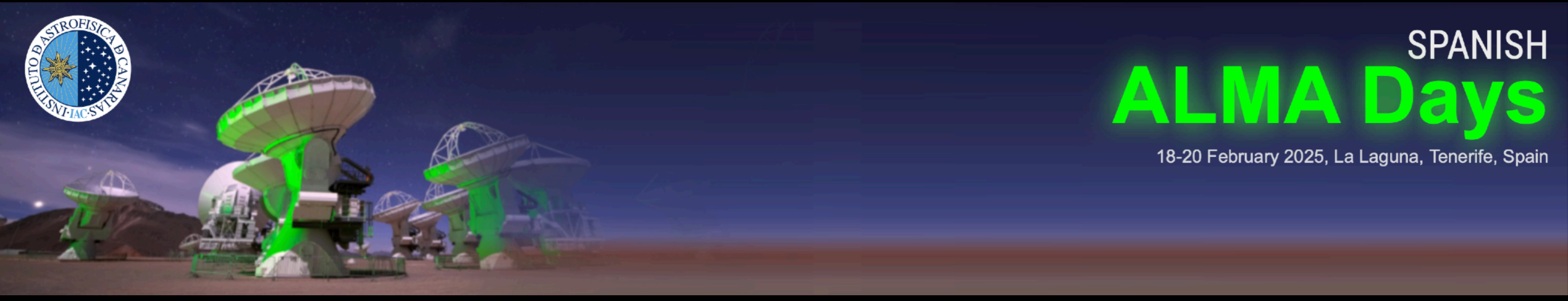
Figure "borrowed" from J. Carpenter

10 + YEARS OF DISCOVERIES





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ALMA Regional Centre



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