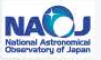




Atacama Large Millimeter/submillimeter Array
In search of our Cosmic Origins



Atacama Large Millimeter/submillimeter Array (ALMA)

John Carpenter

Joint ALMA Observatory (Santiago, Chile)

South American – African Astronomy Coordination Committee (SA3CC) Meeting | May 19, 2026





Why Millimeter/Submillimeter Astronomy?

The Cold Universe

- Stars and planets form in cold molecular clouds
- Cold gas and dust radiate most strongly at millimeter/submillimeter wavelengths

Seeing through dust

- Dust blocks visible light but millimeter waves pass through it
- Reveals where stars are forming

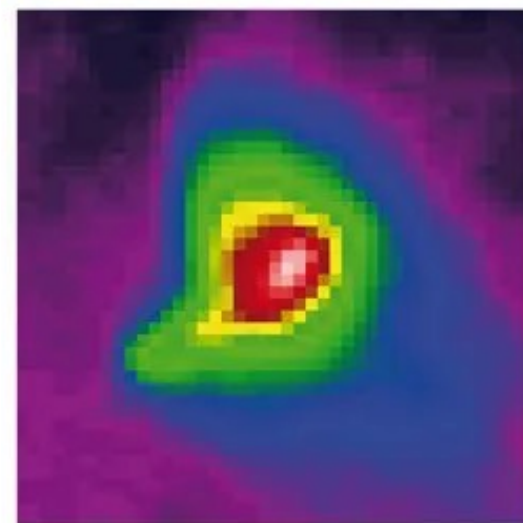
The Molecular Universe

- Molecules emit characteristic signals at millimeter/submillimeter wavelengths
- Reveals the chemical composition of the material
- Traces the kinematics of the gas

Optical



Submillimeter





The ALMA Observatory

66

High-precision antennas

5000 m

Altitude (Llano de Chajnantor)

10

Receiver bands (35–950 GHz)

16 km

Maximum baseline

Location

- Array Operations Site: Llano de Chajnantor, Chilean Andes (5000 m)
- Operations Support Facility: San Pedro de Atacama (2900 m)
- Santiago Central Office: administrative headquarters





An International Partnership

East Asia

NAOJ — Japan, S. Korea, Taiwan

North America

NRAO — USA, Canada, Taiwan

Europe

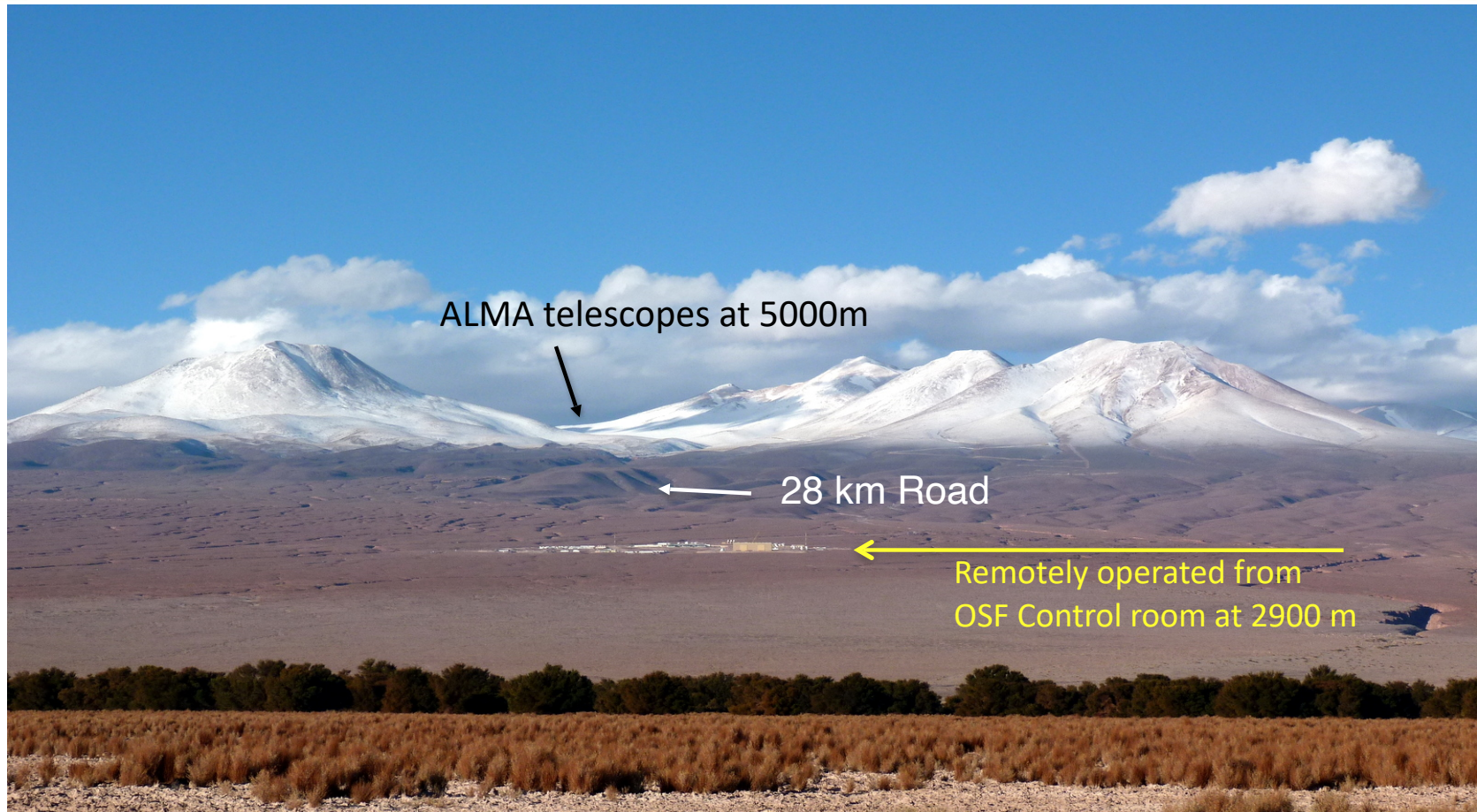
ESO — 16 member states

Chile — Host Country





The ALMA Site





Operations Support Facility (OSF) at 2900 meters





Array Operations Site (AOS) at 5000 meters



Antennas

AOS Technical Building

Correlator





How ALMA Sees the Sky: Interferometry

One Telescope vs. Many

A single dish has limited resolution — determined by its diameter. ALMA combines signals from 66 antennas spread up to 16 km apart, synthesizing a telescope as large as the array itself.

Resolution = Baseline / Wavelength

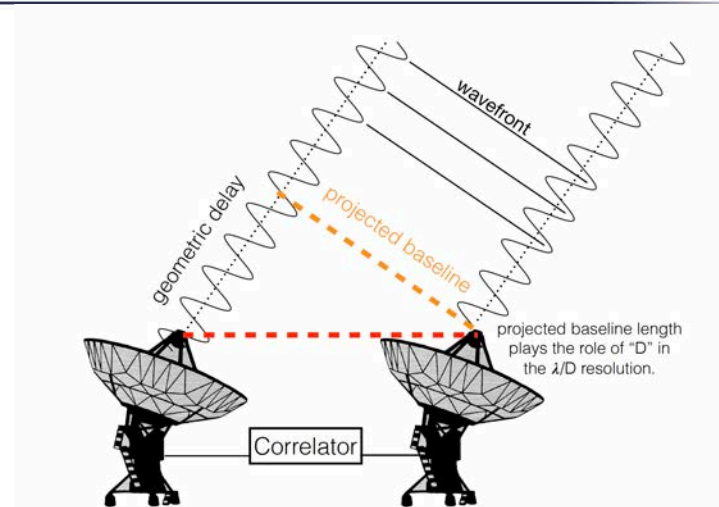
The longer the baseline, the finer the detail ALMA can resolve. At maximum configuration, ALMA achieves sub-arcsecond resolution at millimeter wavelengths.

Configurations

- Compact (160 m): extended emission, large structures
- Extended (up to 16 km): fine detail, compact sources
- Antennas reconfigured several times per year

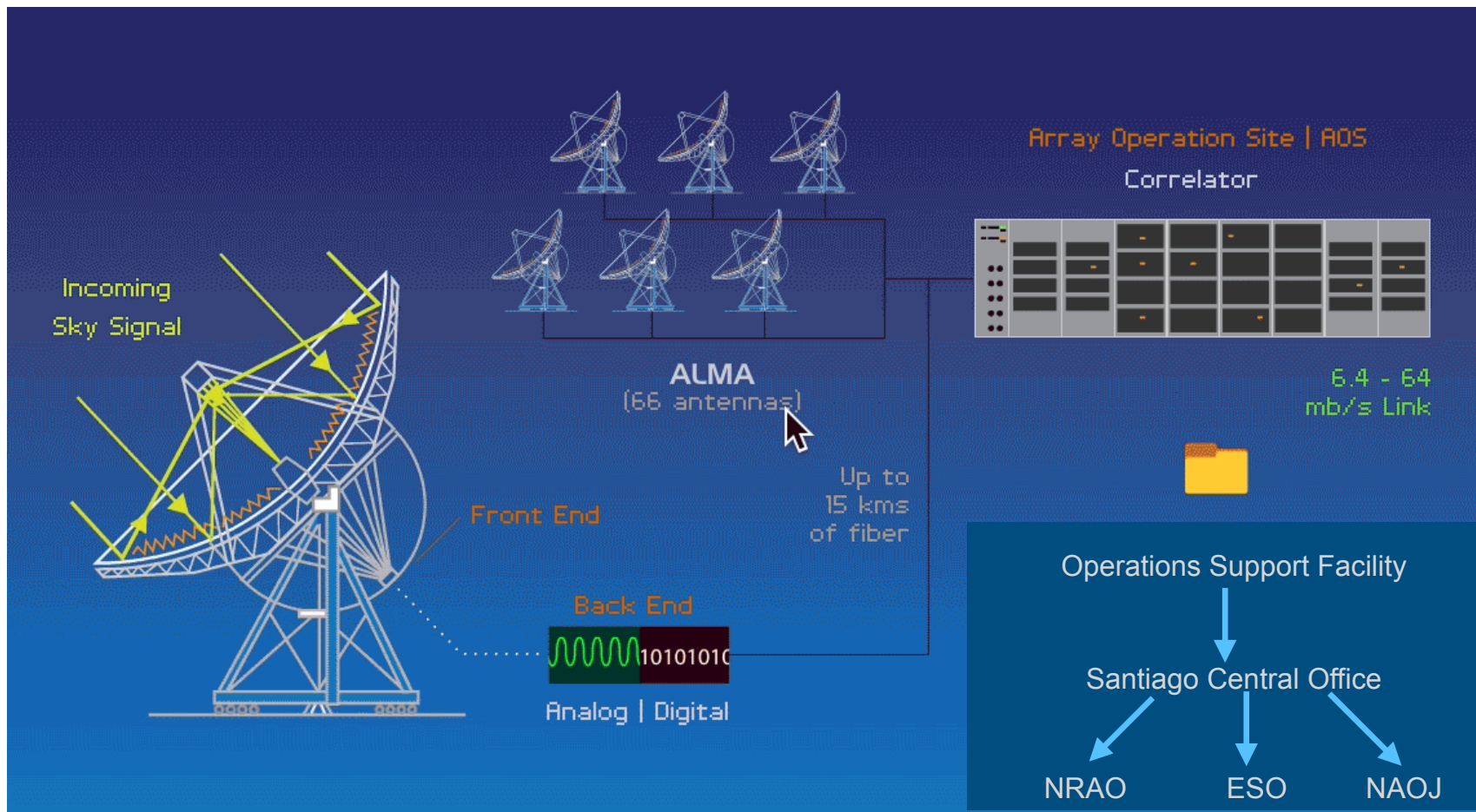
The Correlator

Signals from all antennas are combined in real time by the ALMA correlator — one of the most powerful specialized computers in astronomy.





ALMA Data Flow





From Observation to Science

1

Propose

Astronomers submit proposals and peer-reviewed by the community

2

Observe

Antenna signals combined in real time by the ALMA correlator in Chile

3

Pipeline

Automated calibration and imaging via the ALMA Science Pipeline

4

Archive

Calibrated data deposited in the ALMA Science Archive; public after 12-month proprietary period

5

Support

ALMA Regional Centers (NA, EU, EA) provide expert user support for data analysis

ALMA Regional Centers (ARCs) — User support in three regions

North America ARC

NRAO / NAASC — Charlottesville, VA, USA + Victoria, Canada

European ARC

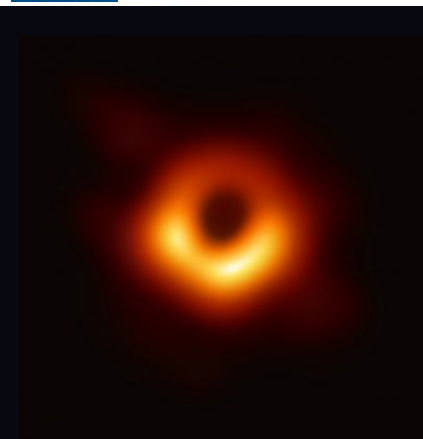
ESO Headquarters + 7 ARC nodes across Europe

East Asia ARC

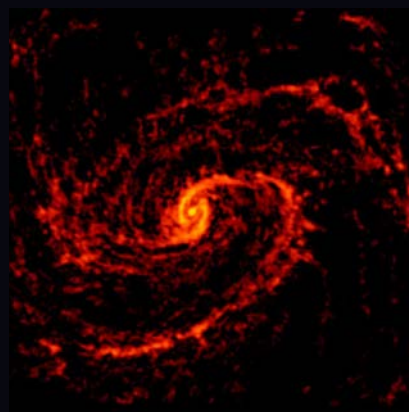
NAOJ (Japan) + ASIAA (Taiwan) + KASI (South Korea)



ALMA Science Highlights



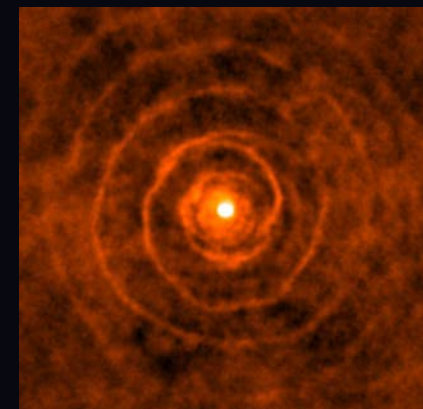
Black Hole
M87, Event Horizon Telescope



Nearby Galaxy
PHANGS: M100 molecular gas



Early Universe
Galaxy at $z=14$, [OIII] 88 μ m emission



Evolved Star
LL Pegasi stellar mass loss



Planet Formation
HL Tau protoplanetary disk



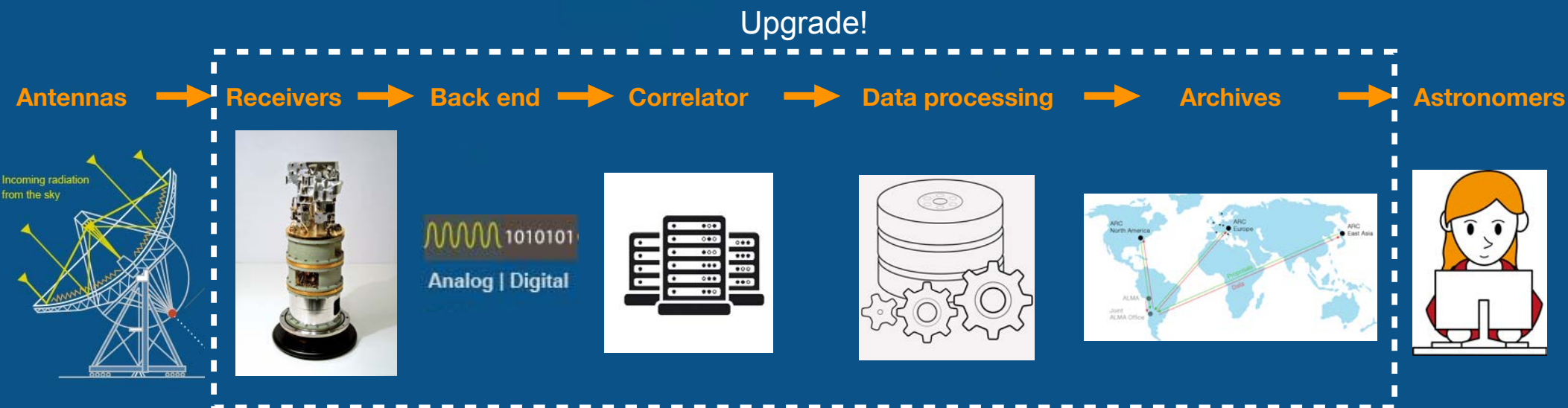
Solar System
Jupiter atmospheric bands



Looking toward the future: Wideband Sensitivity Upgrade (WSU)

Upgrade of the bandwidth and throughput of the ALMA System in progress!

- upgraded receivers with increased bandwidth (up to 4x larger) and improved sensitivity
- new, more powerful correlator; increases spectral line capabilities by an order of magnitude
- increased data reduction capacity





Summary

- ALMA: 66 antennas, 5000 m altitude, 35–950 GHz, baselines to 16 km
- An international observatory serving thousands of astronomers worldwide
- Strong upgrade path to 2030 — sensitivity, bandwidth, new capabilities

