An Introduction to ALMA

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Atacama Large Millimeter/submillimeter Array
Karl G. Jansky Very Large Array
Very Long Baseline Array

NRAO

NRAO: One Observatory, Three World-class Facilities

The National Radio Astronomy Observatory (NRAO) is an FFRDC funded by the NSF for the purpose of radio astronomy. NRAO designs, builds, and operates its own high sensitivity radio telescopes for use by scientists around the world

ALMA: The Atacama Large (sub-)Millimeter Array

ALMA is a telescope for *all* astronomers:

- *Anyone can propose for time on ALMA + ample documentation available*
- *ALMA data delivered after pipeline reduction + all science data is archived*
- *Successful ALMA proposers can get funding to visit NRAO for help with their data*

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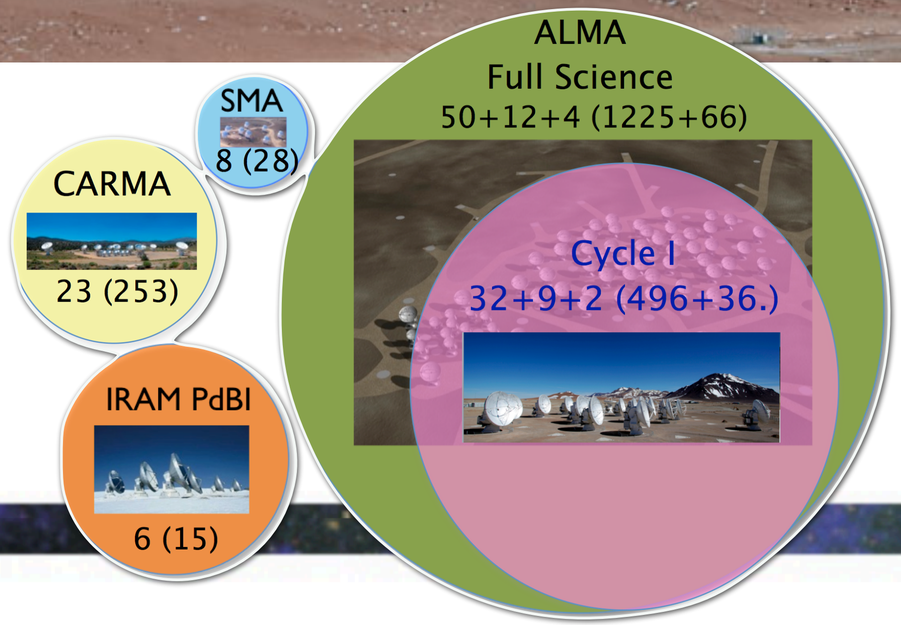
ALMA: The Atacama Large (sub-)Millimeter Array

66 reconfigurable, high-precision 12m or 7m antennas
Main array configurations of 150m – 16km baselines
10 observing bands at 0.32mm – 8.5mm
Site at 16,500ft elevation, -23° latitude
Imaging + spectroscopy



10–100x higher sensitivity & resolution

- *Collecting area → sensitivity*
- *Longest baseline → resolution*
- *No. of baselines → image fidelity*

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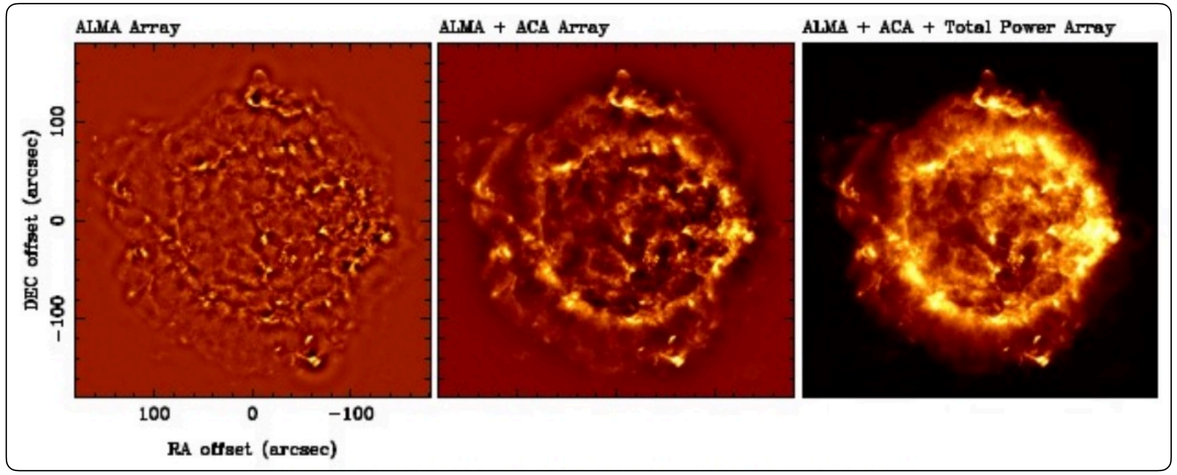
ALMA: Main Array, Compact Array, Total Power Array

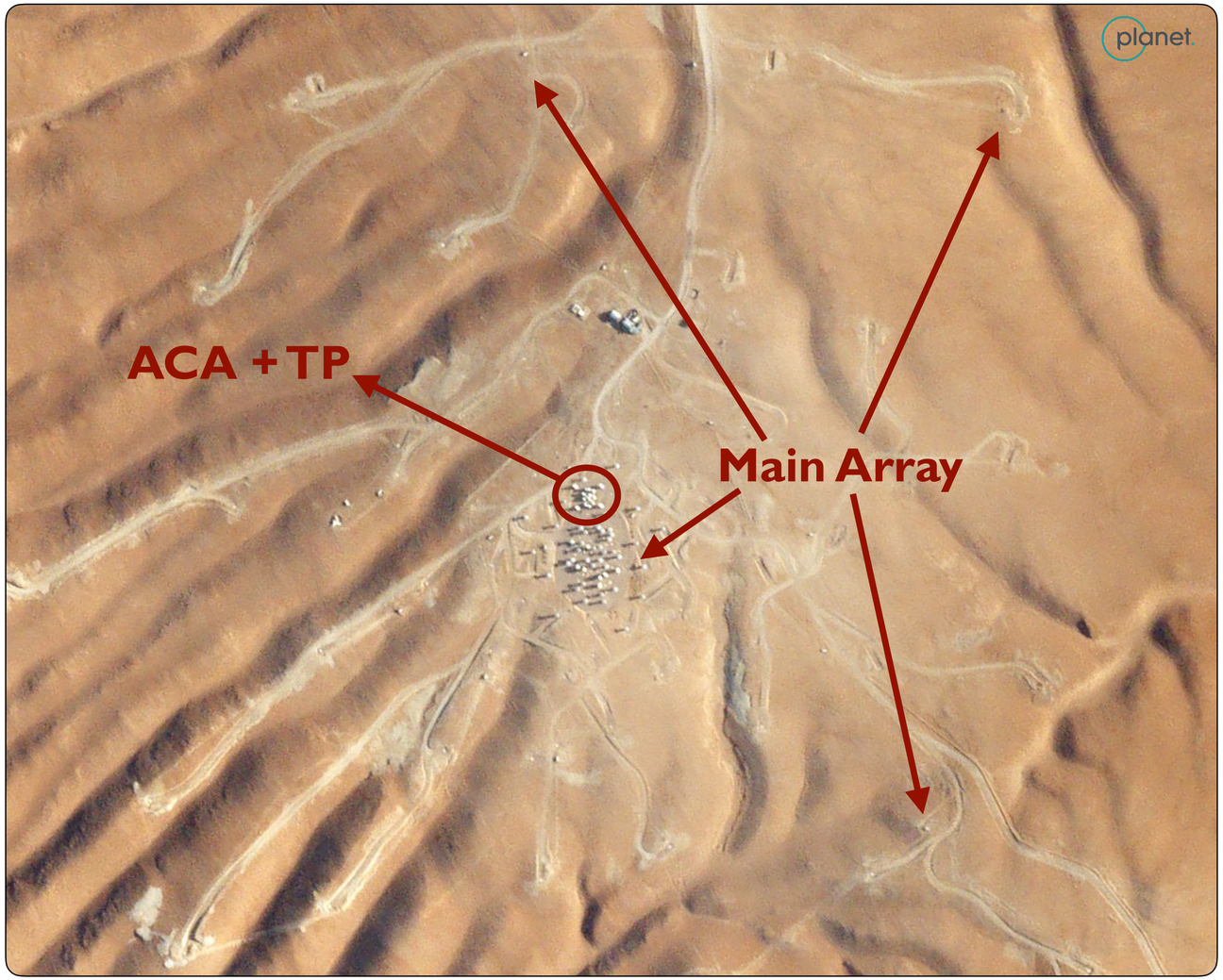
ALMA Main Array: *50x12m antennas <=16 km apart*

Compact Array (ACA): *12x7m antennas, closely spaced*

Total Power (TP) Array: *4x12m antennas, acting as one*



ACA + TP required to recover emission at large angular scales [more in interferometry talk]



ALMA Covers a Wide Range of Science Topics

Sun – coronal mass ejections, magnetic field activity
Solar system, KBOs – atmospheres, astrometry, composition
Star-forming regions – dust/gas environment & kinematics (infall, outflows, jets), protoplanetary disks, cores, chemistry
Exoplanets – direct imaging, gaps in disks, kinematics
Pulsars – neutron star physics, pulse morphology, gravity, ISM probe
Galactic structure – spiral arms, bars, global atomic and molecular gas properties
Nearby galaxies – molecular/atomic gas content & kinematics, galaxy dynamics at high resolution, obscured star formation
Galaxy groups and clusters – atomic/molecular gas across systems, star formation efficiency, kinematics, dynamical masses
Black holes – mass measurements, kinematics
High redshift galaxies – extragalactic background light, source counts, star formation history/efficiency, evolution of gas
Cosmology – H_0 measurement, SZE

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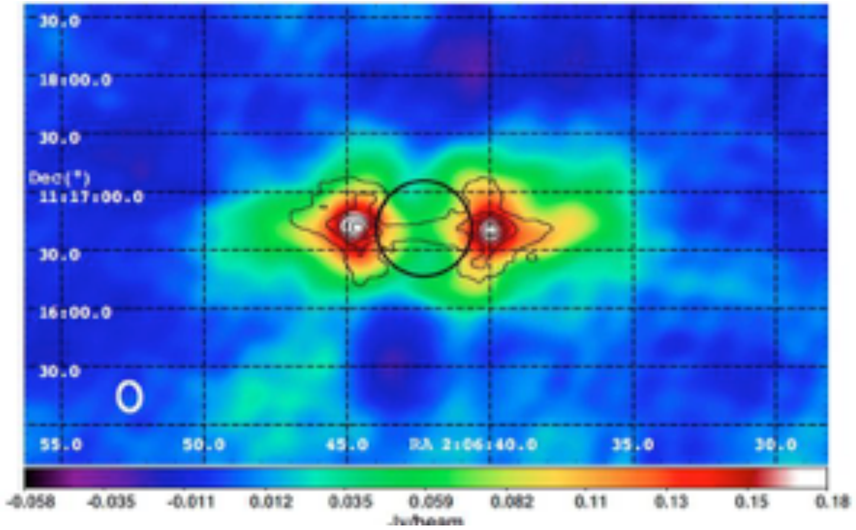
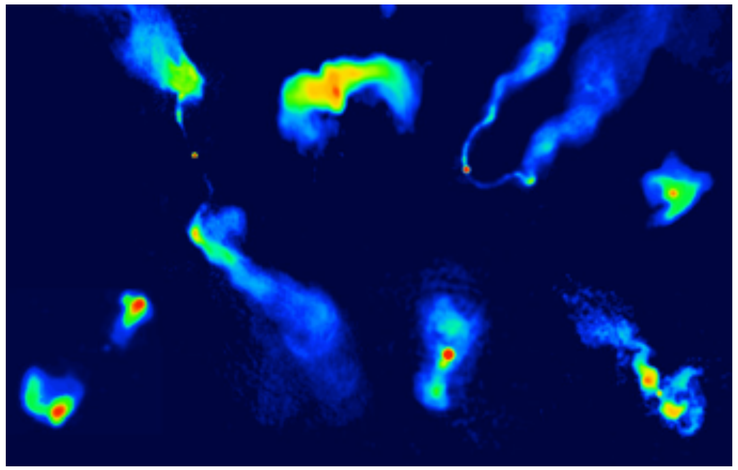
What Can You Observe With ALMA?

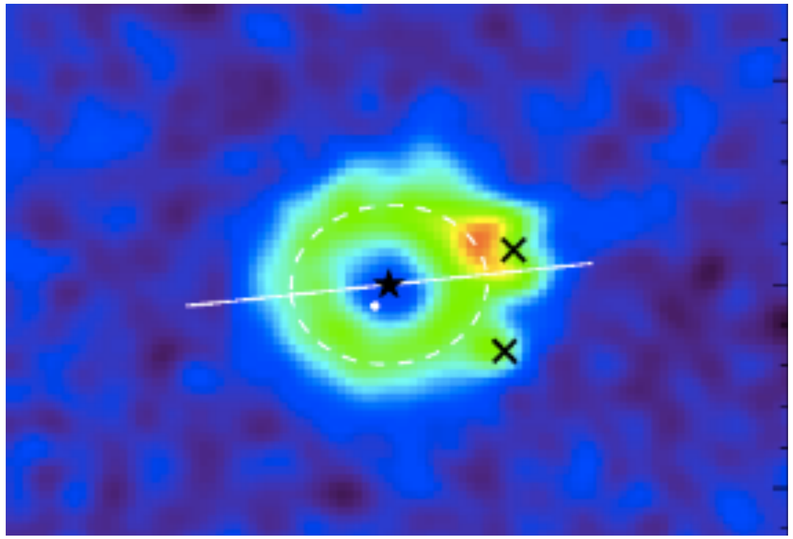
Jupiter's radiation belt at 100 MHz (300 cm)



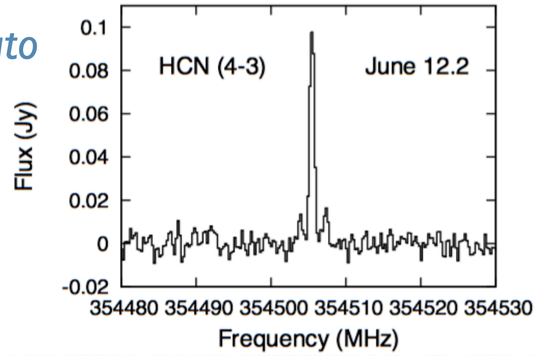


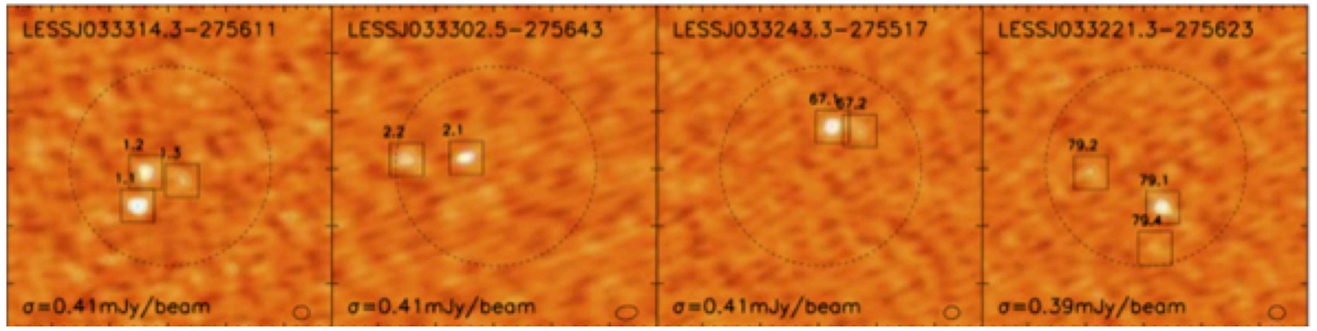
Synchrotron emission from extended radio galaxies (5 GHz)

Kuiper belt analogs round Sun-like stars



Organics on Pluto (Lellouche+16)





100s of high-z sub-mm galaxies (Hodge+13)

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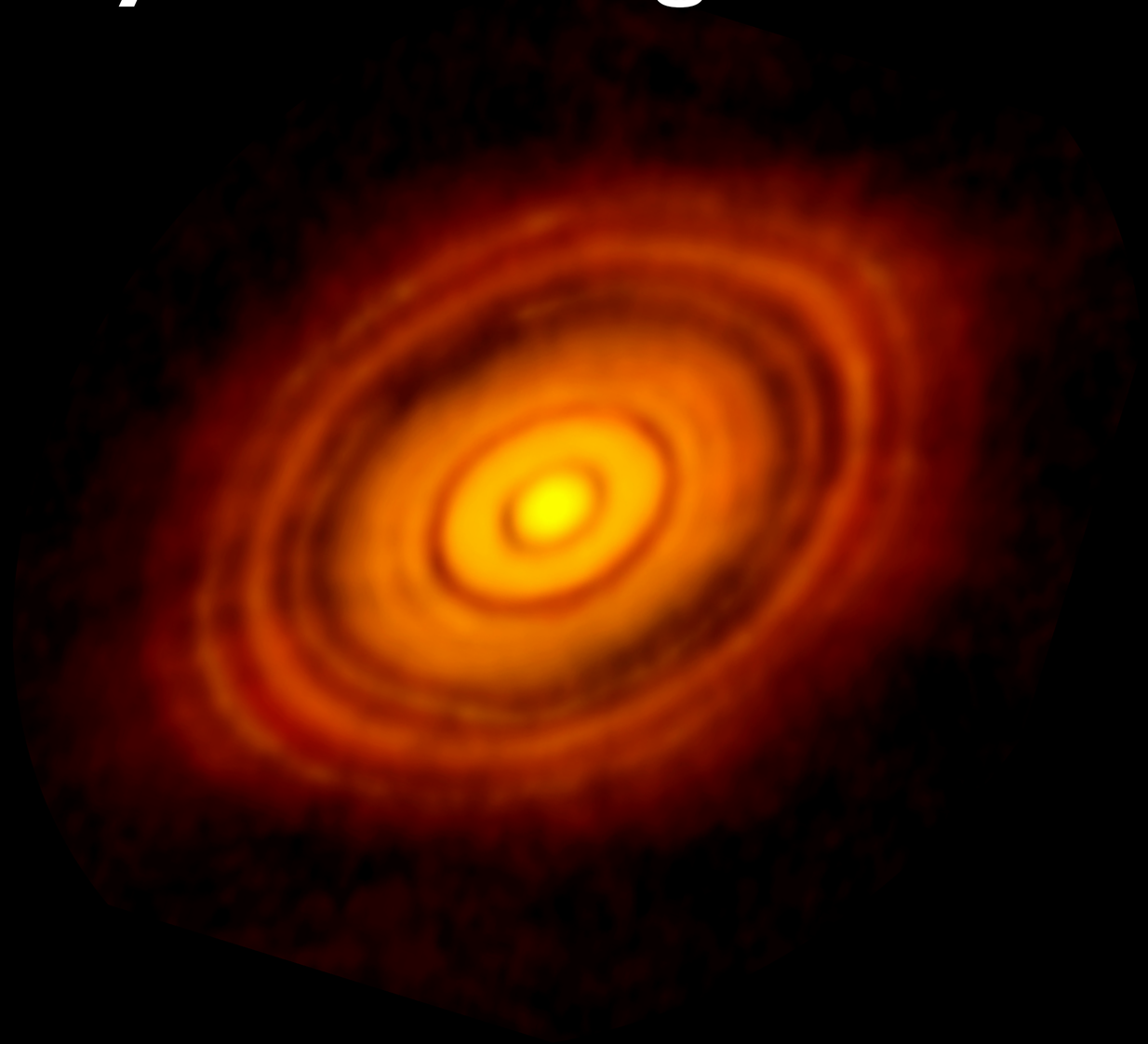
Protoplanetary disks at high resolution

HL Tau
pre-ALMA resolution
0.2″ at 140 pc (30 AU)

Protoplanetary disks at high resolution



HL Tau

15 km baselines w/ALMA

0.025″ at 140 pc (3.5 AU)