Welcome to Arizona ALMA Community Day!

Irene Shivaei

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

Agenda

9:15 – 9:45	Introduction to NRAO/ALMA (Irene Shivaei)
9:45 – 10:30	Introduction to Radio Interferometry (Steve Ertel)
10:30 – 10:45	**Coffee Break**
10:45 – 11:15	ALMA Capabilities (Nick Ballering)
11:15 – 11:30	Distant Galaxies with ALMA (Dan Marrone)
11:30 – 11:45	Investigating Planet Formation with ALMA (Paola Pinilla)
11:45 – 13:00	**Lunch Break**
13:00 – 13:20	Proposal Preparation (Nick Ballering)
13:20 – 13:40	Next Steps After Submission (Irene Shivaei)
13:40 – 14:10	Intro to Imaging and Simulations with CASA (Steve Ertel)
14:10 – 14:40	Observing Tool Demo (Nick Ballering)
14:40 – 15:00	**Coffee Break**
15:00 – 17:00	Free time to work on proposals/OT preparation

Wifi Available:

Two Options:

1) eduroam

2) Guest wifi network: UAGuest

You need to register with your phone number

Software to Download

If you haven't downloaded in advance, you may need ALMA Observers Tool and CASA to participate in the afternoon session

ALMA OT

https://almascience.nrao.edu/proposing/observing-tool

Download the webstart version (will automatically download the most recent version each time you open it)

CASA

https://casa.nrao.edu/casa_obtaining.shtml

Download most recent version 5.1.2

Where Can I Get Help After This Workshop?

ALMA Helpdesk	Questions answered within 48 hours (around the clock staffing in the week leading up to the proposal deadline) https://help.almascience.org
Student Observing Support	Up to $35k to support undergraduate or graduate student involvement in successful ALMA proposals https://science.nrao.edu/opportunities/student-programs/sos
Page Charges	Support available upon request for authors from US institutions reporting ALMA/VLA results https://library.nrao.edu/pubsup.shtml
Face-to-face Visits	NRAO covers travel expenses for up to 2 people from 2 teams per week to get support for data reduction, proposal preparation, etc. at the NAASC https://science.nrao.edu/facilities/alma/visitors-shortterm
ALMA Ambassadors	You too can become an ALMA Ambassador! https://science.nrao.edu/facilities/alma/ambassadors-program

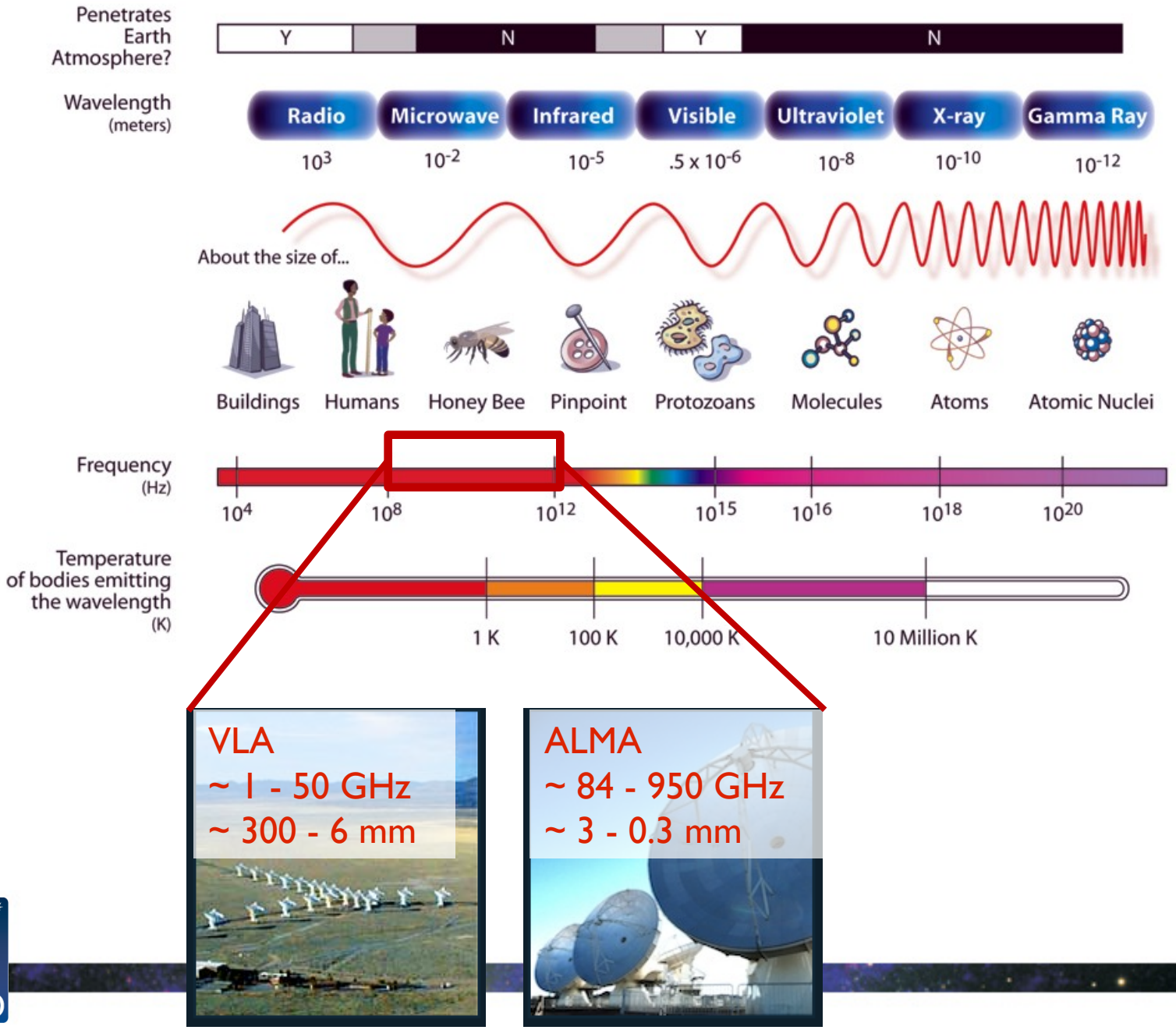
All of the presentations will be uploaded on the website after the community

ALMA flyers and documents are available for you on the side desks

NRAO:
One Observatory, Two World Class Facilities

Other Affiliated Telescopes and Observatories include the Green Bank Observatory (http://greenbankobservatory.org/) and the Long Baseline Observatory (https://www.lbo.us/)

NRAO


Penetrates Earth Atmosphere?
Y
N
Y
N
Wavelength (meters)
Radio
Microwave
Infrared
Visible
Ultraviolet
X-ray
Gamma Ray
10^3
10^-2
10^-5
.5 x 10^-6
10^-8
10^-10
10^-12
About the size of...
Buildings
Humans
Honey Bee
Pinpoint
Protozoans
Molecules
Atoms
Atomic Nuclei
Frequency (Hz)
10^4
10^8
10^12
10^15
10^16
10^18
10^20
Temperature of bodies emitting the wavelength (K)
1 K
100 K
10,000 K
10 Million K
VLA
~ 1 - 50 GHz
~ 300 - 6 mm
ALMA
~ 84 - 950 GHz
~ 3 - 0.3 mm

NRAO:
One Observatory, Two World Class Facilities

Atacama Large Millimeter/submillimeter Array:
a 66-antenna array in Chile

What is ALMA?

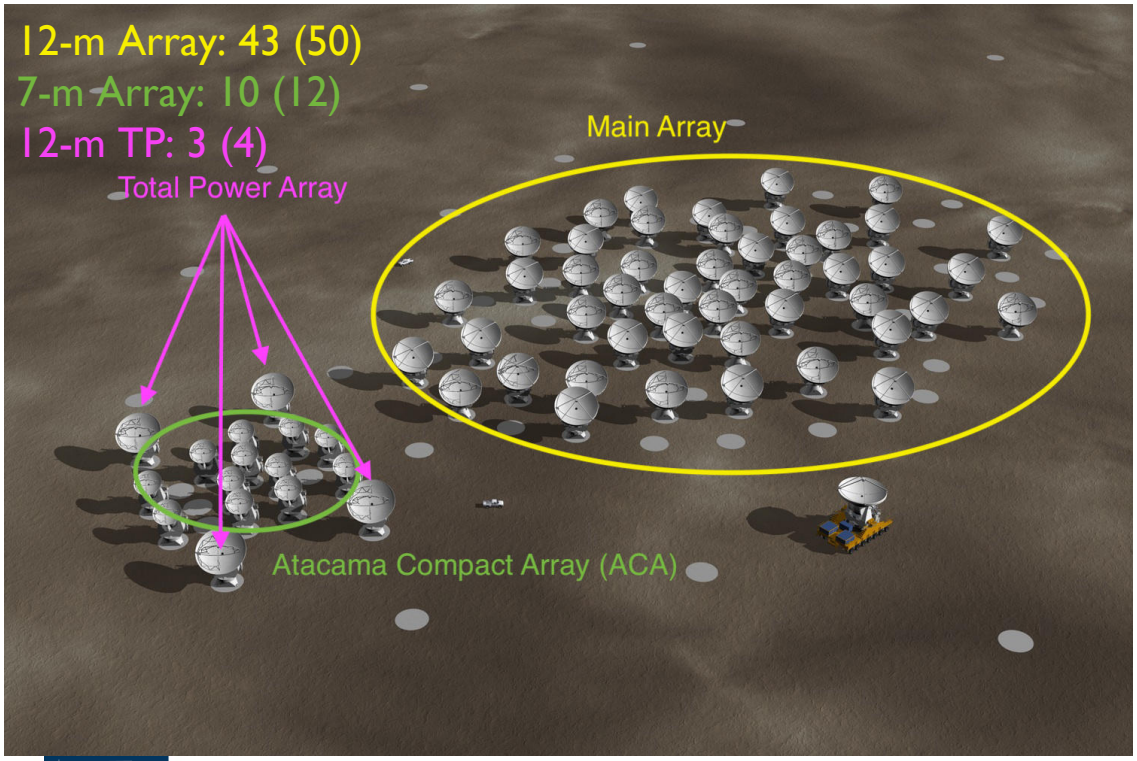
Array Operations Site is located at 5000m elevation in the Chilean Andes – one of the driest locations on earth

Operations Support Facility (OSF) is at an elevation of 2900m

What is ALMA?

66 reconfigurable, high precision antennas
Imaging and spectroscopic instrument, operating at

$\lambda \sim 0.32 - 3$mm (eventually to 8.5mm)



What is ALMA?

Array configurations between 150 meters and >16 kilometers
Array operations are the responsibility of Join ALMA Observatory (JAO)

ALMA antennas movement from September 17, 2009 to December 7, 2014:

http://youtu.be/YMISe-C8GUs

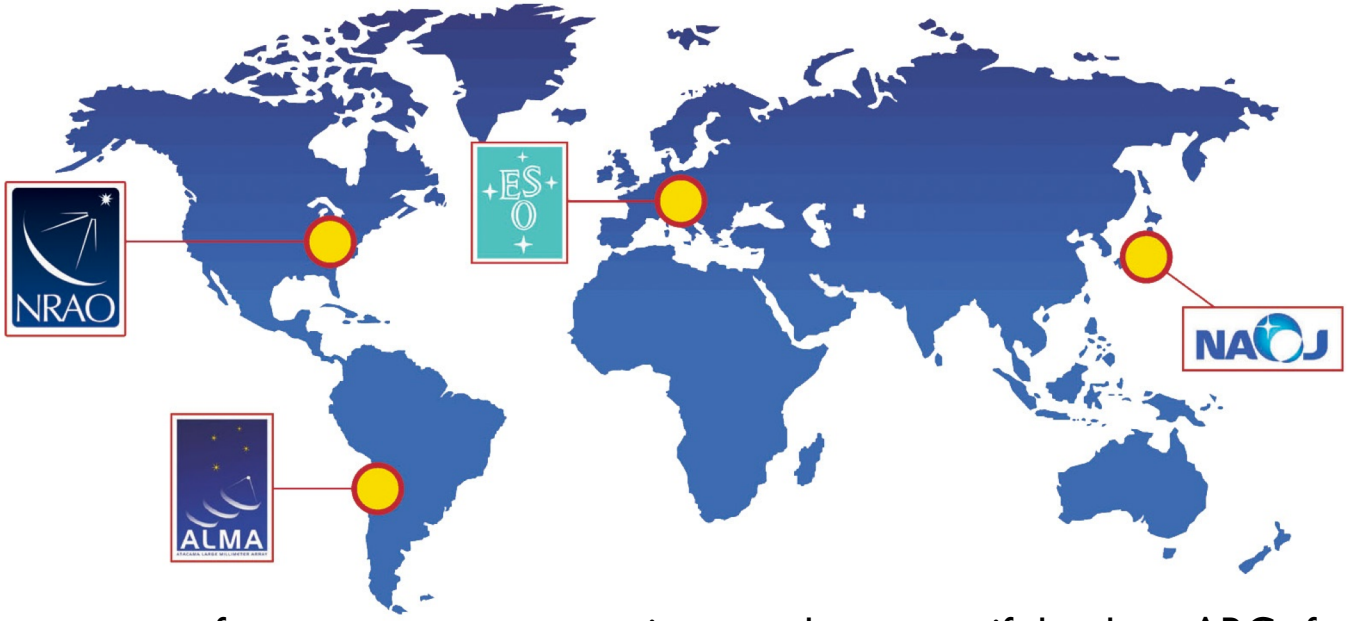
What is ALMA?

A global partnership (in collaboration with Chile)

- North America
- Europe
- East Asia

ARC: ALMA Regional Center: interface between observatory and the community

North American ARC is part of the North American ALMA Science Center (NAASC), based at NRAO in Charlottesville



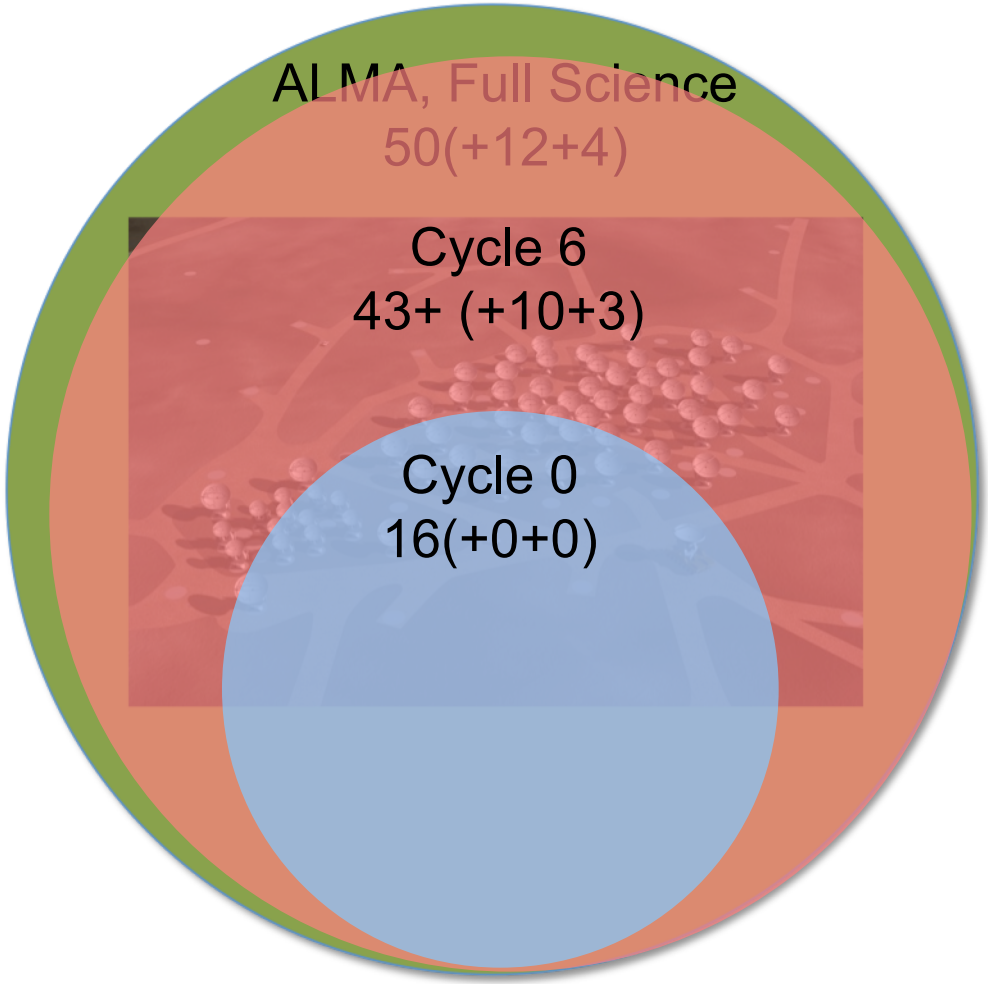
Astronomers from non-partner countries may choose any if the three ARCs for support

NRAO

What is ALMA?

Collecting Area

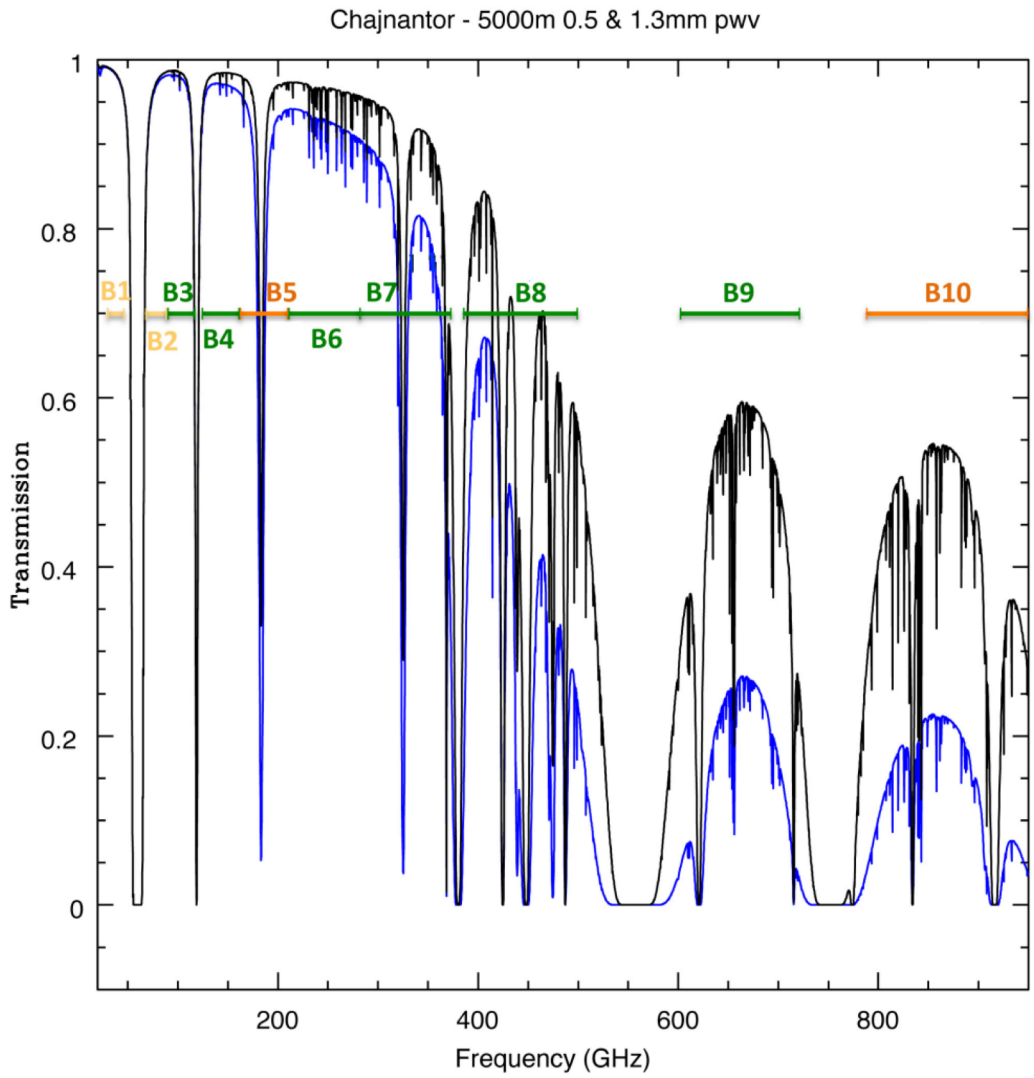
Not only sensitivity but the collecting area (1.6 acres or 6600+ m^2) + huge number of baselines provides excellent image fidelity



What is ALMA?

Spectral Coverage

Covers ten atmospheric windows with 50% or more transmission above 35 GHz



https://almascience.nrao.edu/proposing/about-alma/atmosphere-model

ALMA Current Status

- Construction Project ended in September 2014
- Routine science observing has been out to **greater than 12 km baselines (C40-9)** thanks to the highly successful Long Baseline Campaigns in 2014 and 2015
- **All 66 antennas accepted**
  - Currently all 66 antennas are at the high site (AOS), of which ~47 on average (up to max ~54) are being used for Cycle 5 observations
  - Some construction and verification items remain to be finished (e.g., wide-field polarization; various observing modes)
- The ACA (Atacama Compact Array) or Morita Array – up to 12x7m antennas and 4x12m antennas for TP observations – is currently being used for Cycle 5 observations
- More on Capabilities later… however, first on to science!

Broad Science Topics with NRAO Telescopes

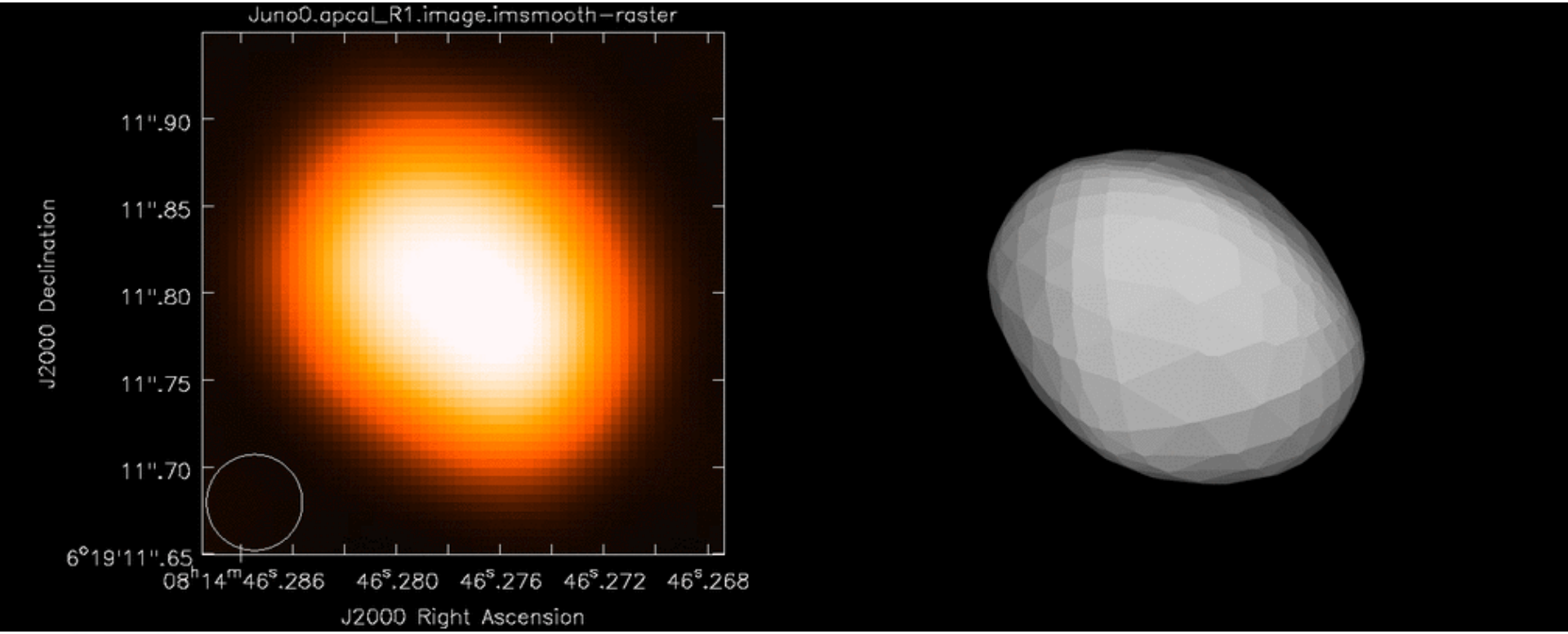
- Sun – coronal mass ejections, magnetic field activity
- Solar system, KBOs – atmospheres, astrometry, composition
- Star-forming regions – dust and gas environment, kinematics (infall, outflows, jets), proto-planetary disks, cores, chemistry, feedback, and natal cloud / star interactions
- Exoplanets – 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 and kinematics, dynamics of galaxies at high resolution, star formation, obscured SF, gas flow
- Galaxy groups and clusters – atomic and molecular gas across systems, star formation efficiency, kinematics, dynamical mass measurements
- Black holes – mass measurements, kinematics
- High redshift galaxies – extragalactic background light, source counts, star formation history and efficiency, evolution of gas content (atomic and molecular)
- Cosmology – H_0 measurement, SZE

ALMA Science Highlights: Solar System

Band 6 Observations of Juno Asteroid

Five consecutive executions over 4.4 hours

Beamsize ~ 0.04”x0.03” (~60x45 km)



ALMA Image of Juno (ALMA Partnership, Hunter et al. 2015)

Model: Durech et al. 2010

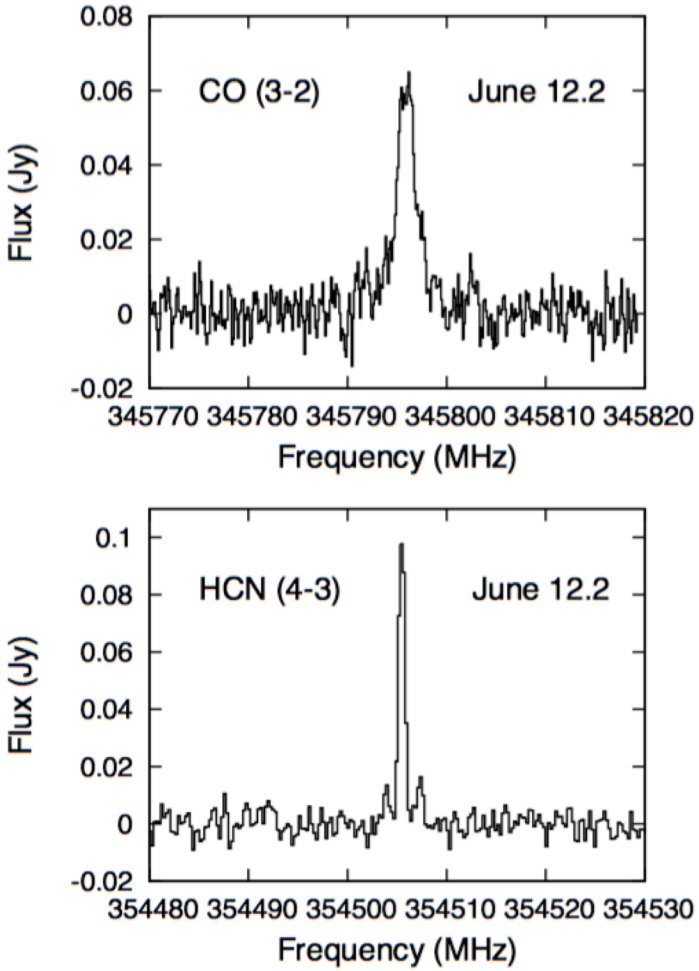
ALMA Science Highlights: Solar System

ALMA detects organics on Pluto

ALMA has detected CO(3-2) and HCN (4-3) on Pluto

The lines probe the abundances and temperature of Pluto's atmosphere up to ~450 km and ~900 km.

Lellouche et al. 2016

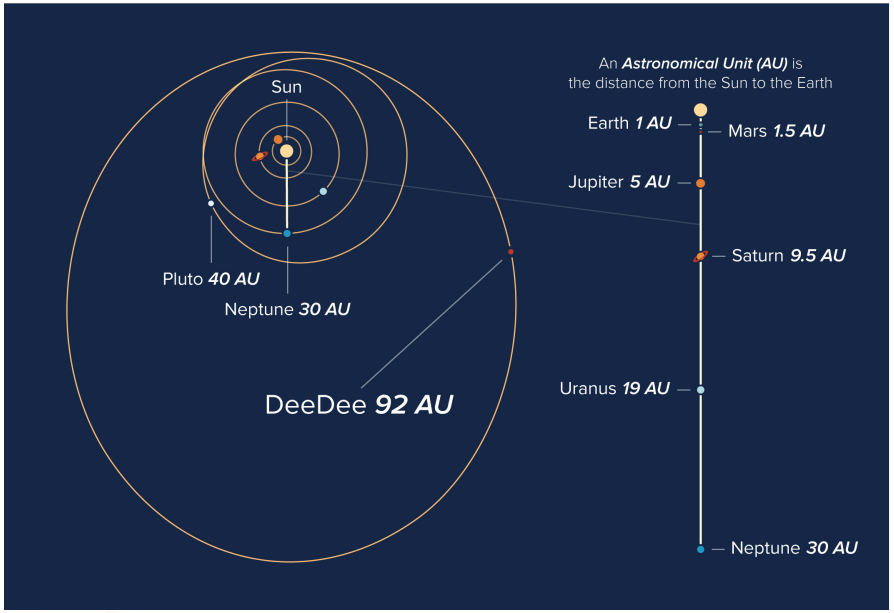


ALMA Science Highlights: Solar System

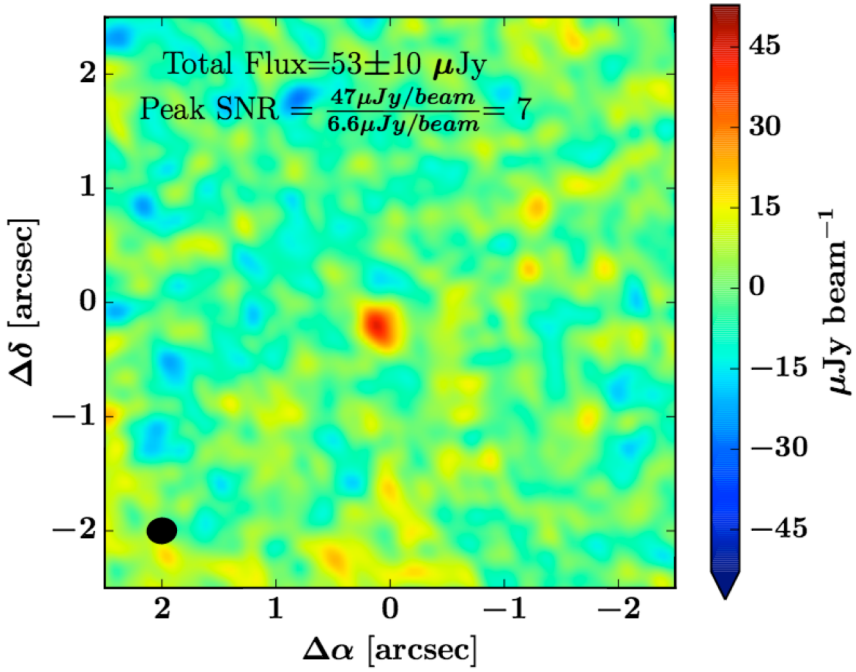
ALMA Characterizes TransNeptunian Object

ALMA imaged 2014 UZ_{224}, or DeeDee* at 92 AU, measuring its thermal properties

It's the 2nd most distant confirmed Solar System object, with a surface at 30K. Very dark, its albedo is only 13%.

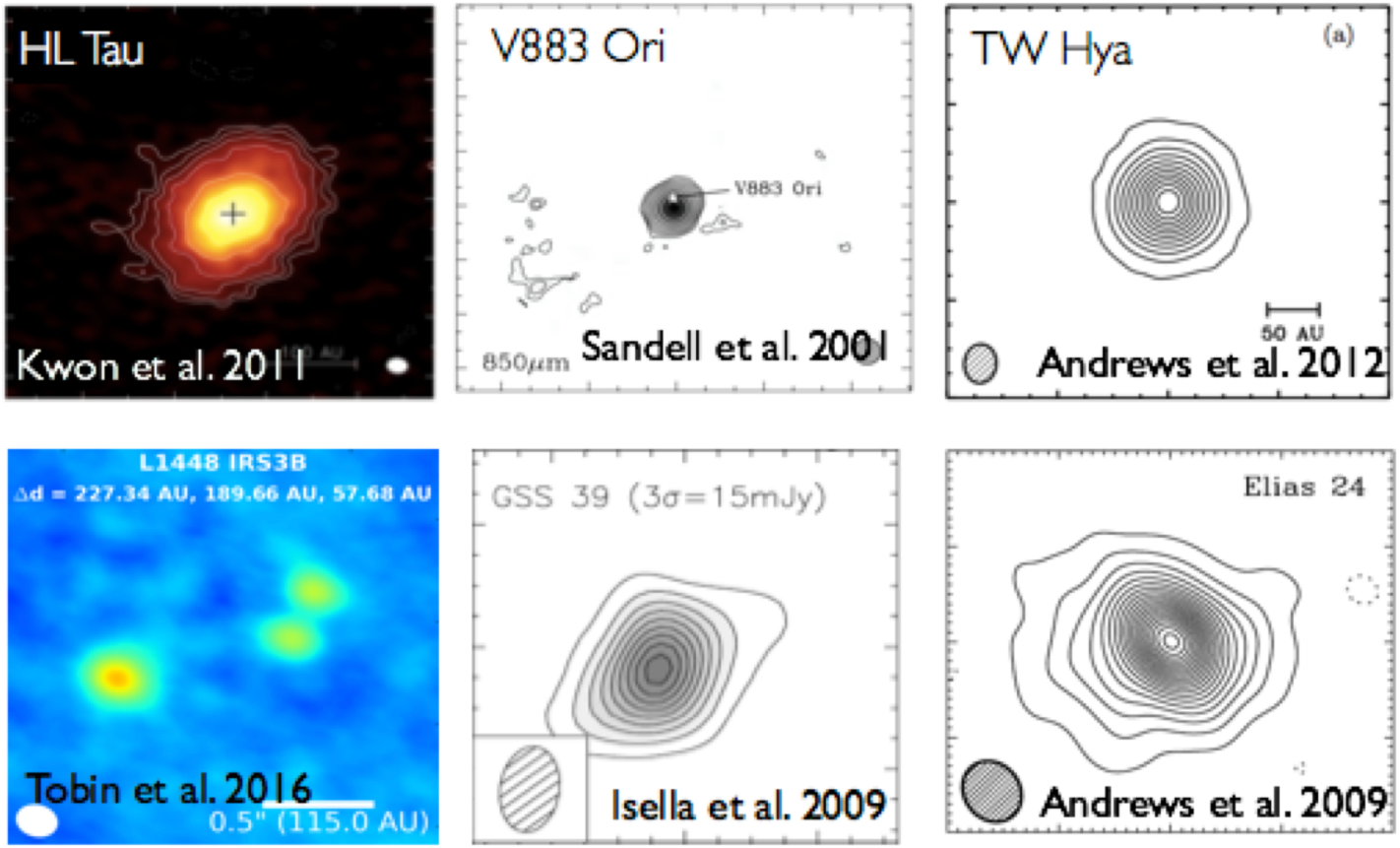


Gerdes et al., 2017 *ApJL*, **839**, L15.



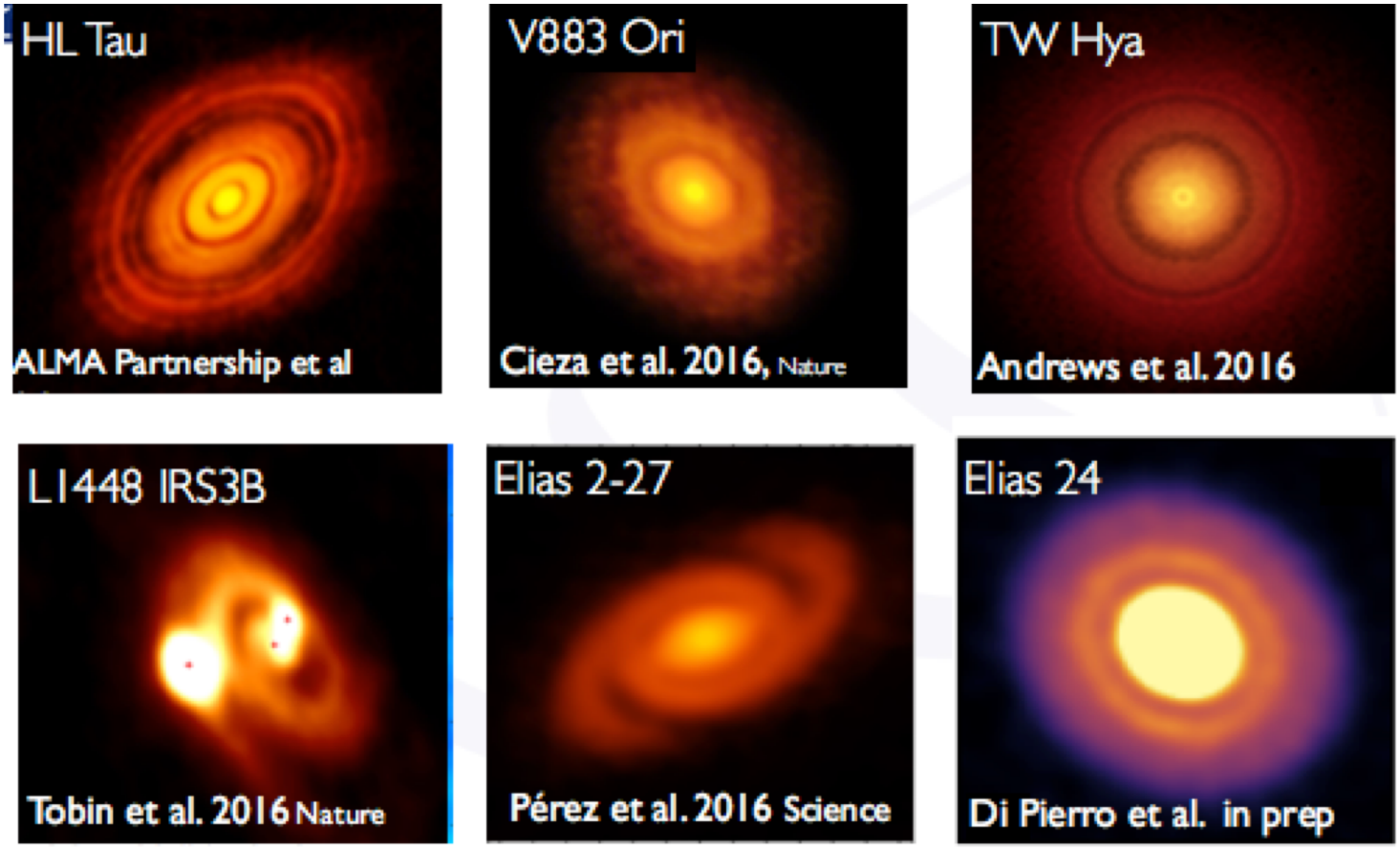
ALMA Science Highlights: Protoplanetary Disks

Protoplanetary Disks: Pre- ALMA



ALMA Science Highlights: Protoplanetary Disks

Protoplanetary Disks: With ALMA



Composite image courtesy J. Carpenter / A. Wootten (ALMA / NRAO)

ALMA Science Highlights: Debris Disks

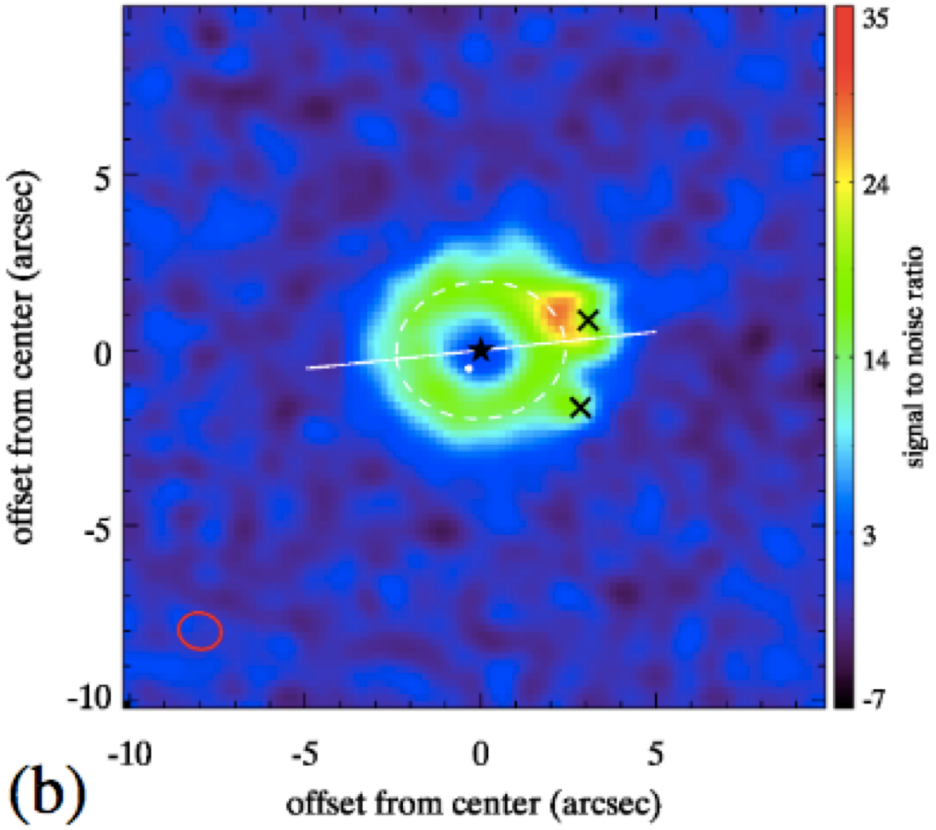
ALMA Images A Kuiper Belt Analogue Around Sun-like Star

ALMA has imaged a debris disk outside the planetary orbit

The disk extends from an inner radius ~100 AU to an outer radius ~320 AU.

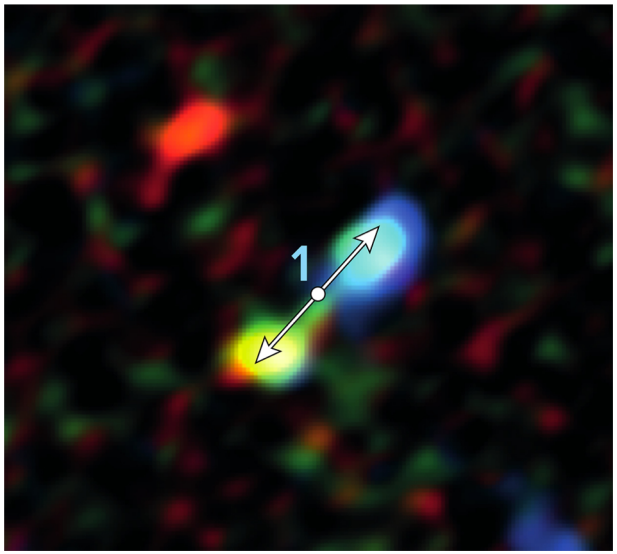
A second planet may shepherd the inner edge of the cold disk, could be 0.2-1.5M_{jup}

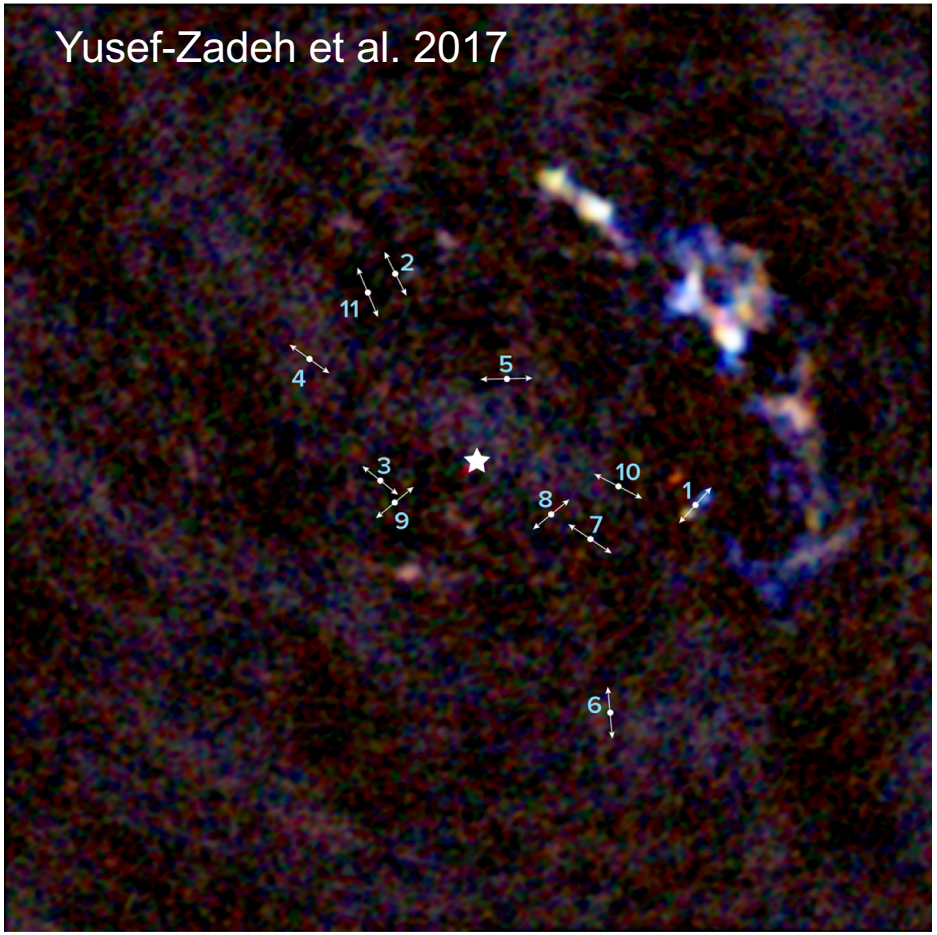
Su et al. 2017



ALMA Science Highlight: Milky Way

ALMA detects bipolar outflows in 11 young protostars within 1 parsec of Sagittarius A*

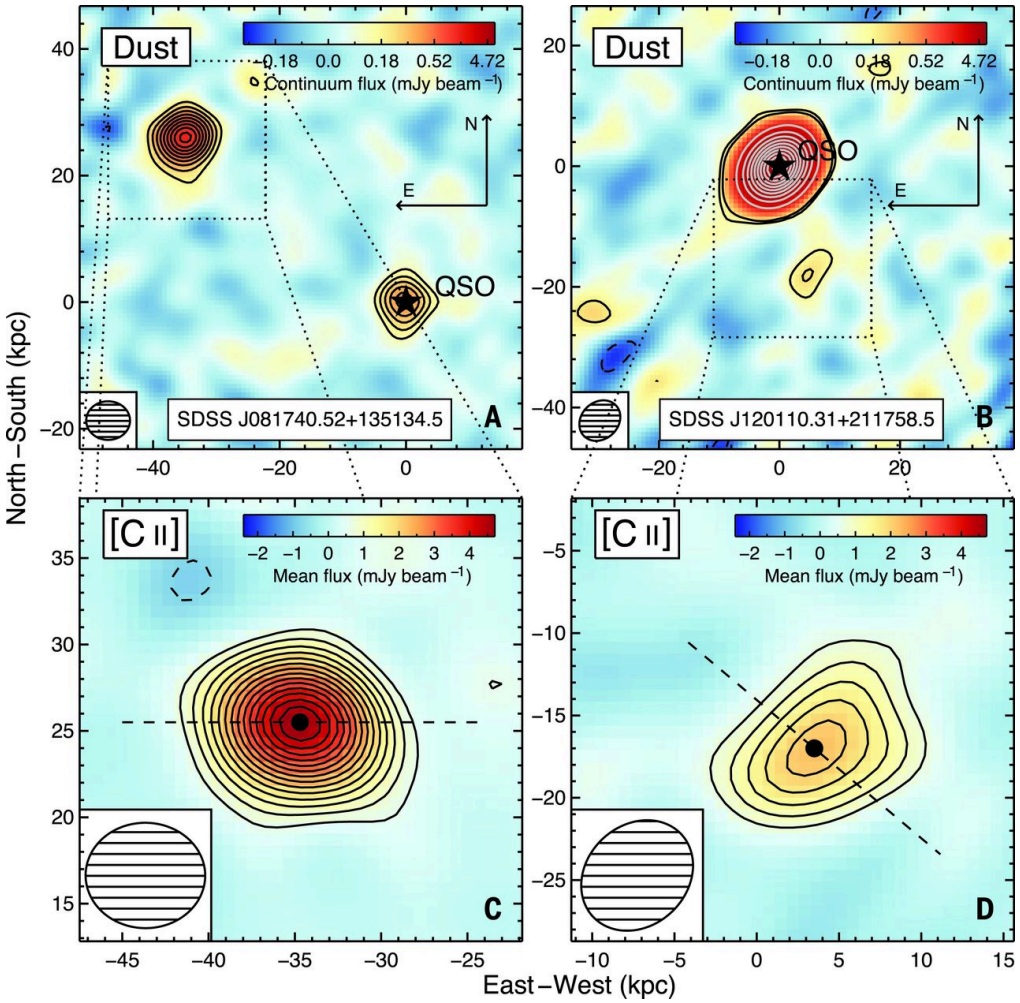




ALMA Science Highlight: Extragalactic

Neeleman et al. Science 2017

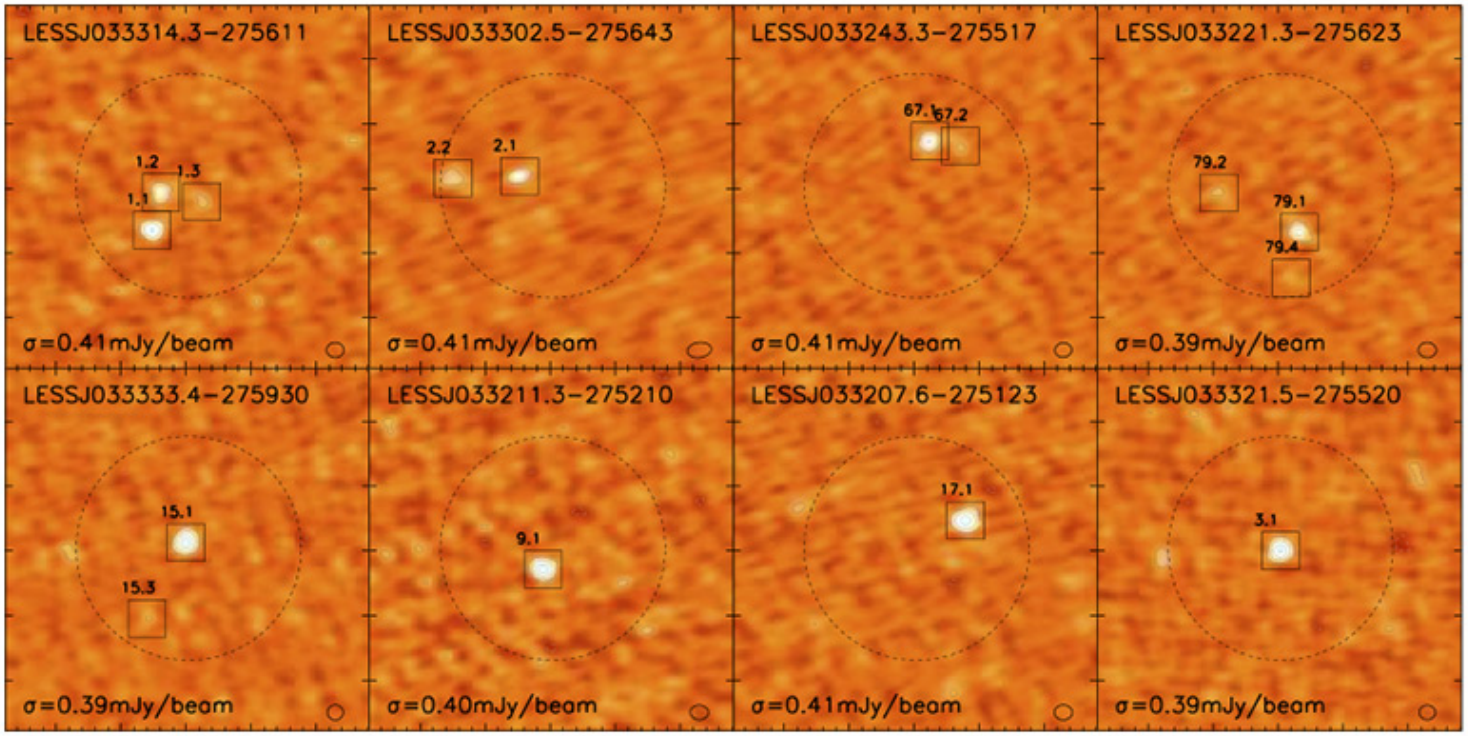
ALMA: SuperHaloes Surround Early Milky-Way-like Galaxies at z~4



ALMA Science Highlights: the Distant Universe

Resolving High-z Submm Galaxies

Hodge et al. 2013



99 sources detected in 88 fields, integration time ~120 sec (!!)

2x deeper, 10x higher angular resolution than previous surveys

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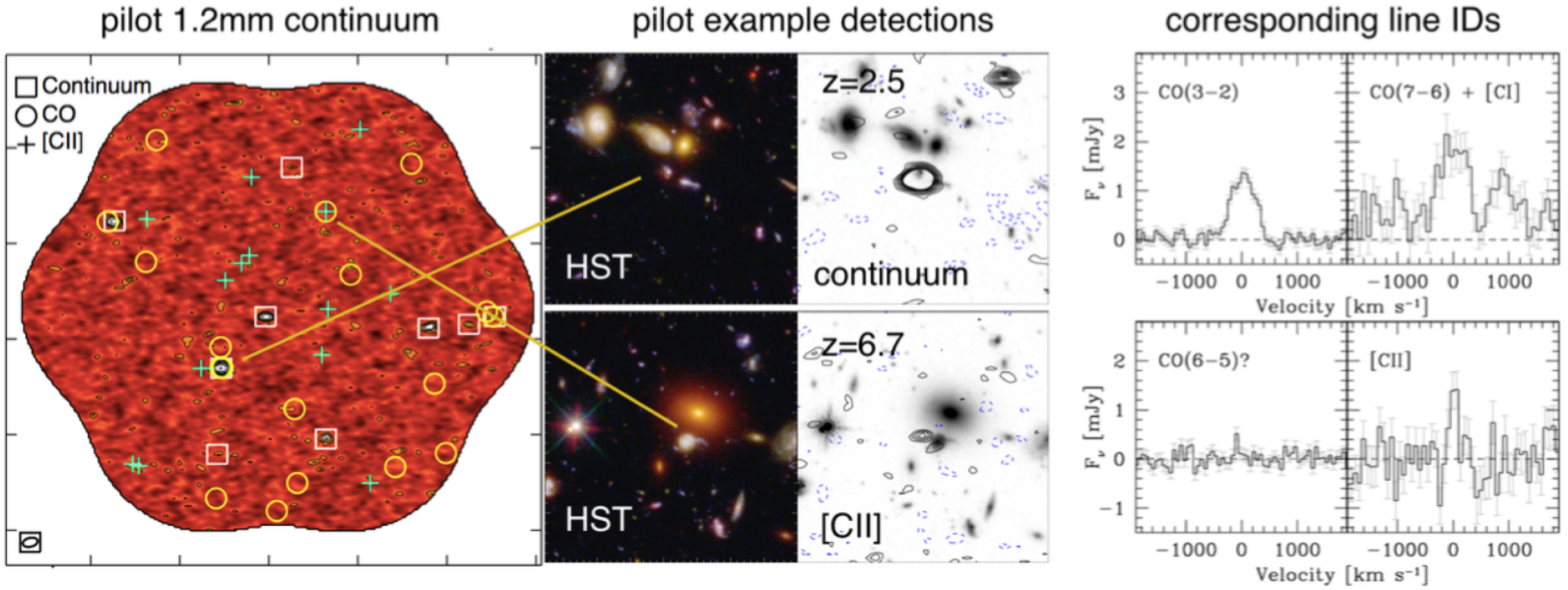
ALMA Science Highlights: the Distant Universe

ALMA Deep Fields

- 21 candidate line galaxies were detected, including CO emission from galaxies at z=1 to 5, and [CII] at z > 6, plus 9 dust continuum sources at 1.2mm
- These data determine the dense gas history of the Universe, the necessary complement to the star formation history of the Universe.



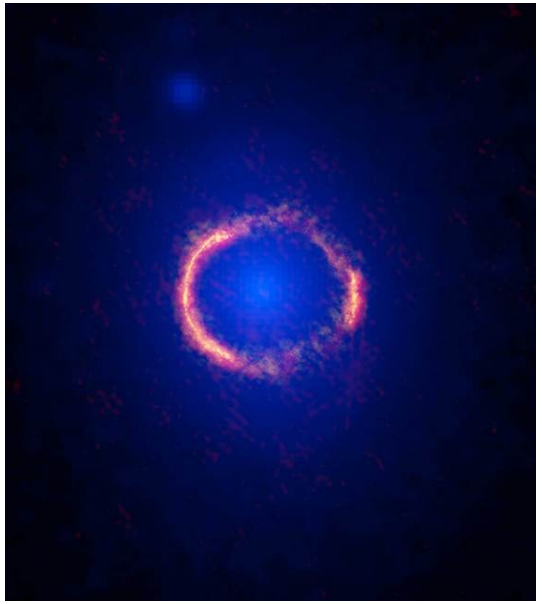
ALMA Science Highlights: the Distant Universe

ALMA's potential to advance understanding of dark matter substructures

ALMA's SDP.81 observations are analyzed to detect a subhalo with a mass of $10^{8.96 \pm 0.12}\ M_{sun}$

Observations of larger samples of gravitational lenses with ALMA should be able to improve the constraints on the abundance of galactic substructure.

Hezaveh et al. (2016)



The SDP.81 system.

Blue: HST/WFC3 F160W data shows lensing elliptical at z~0.3

Red: ALMA Bands 4/6/7 combined emission.

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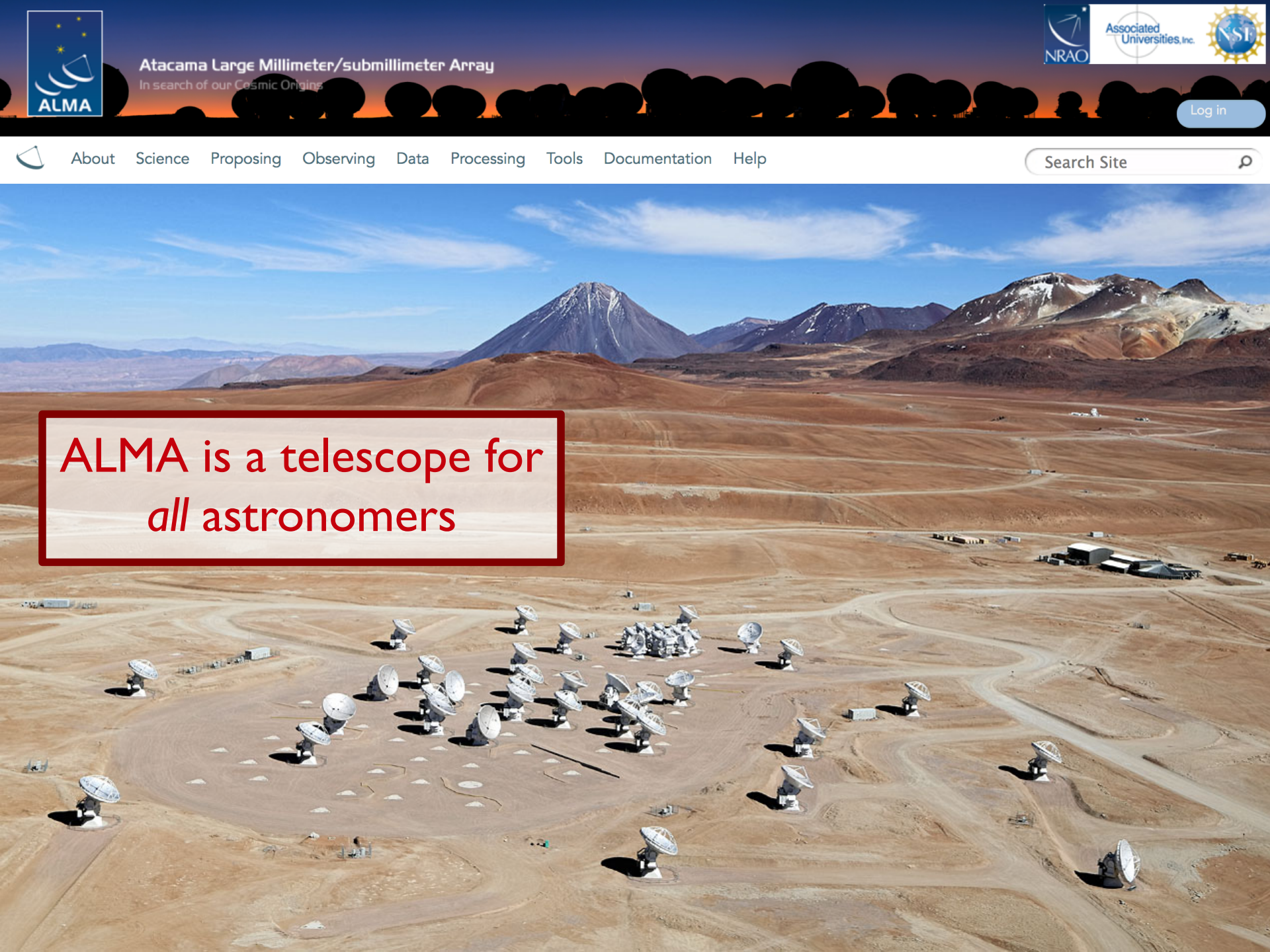
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