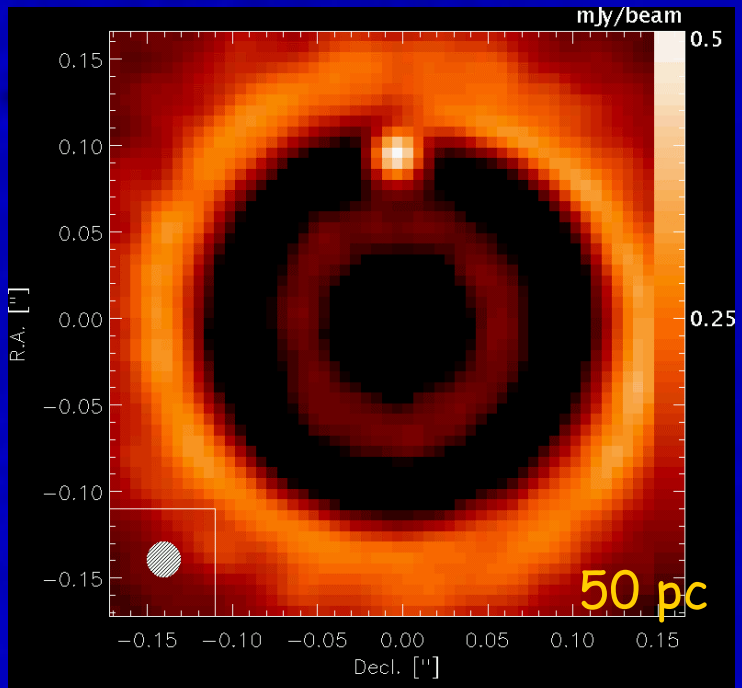
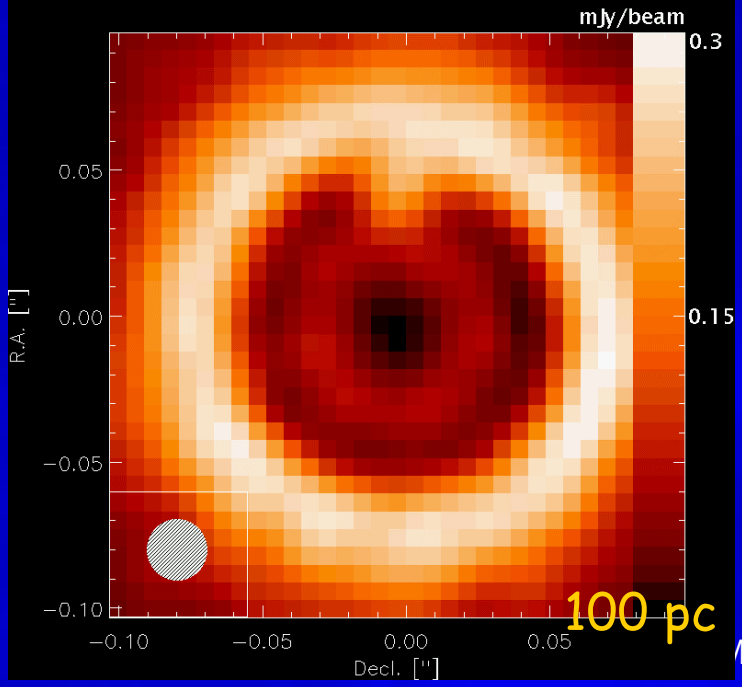
Current Status of ALMA Commissioning and Science Verification

Alison Peck
Deputy Project Scientist





ALMA Key Science 1:

Planetary regions, nearby disks

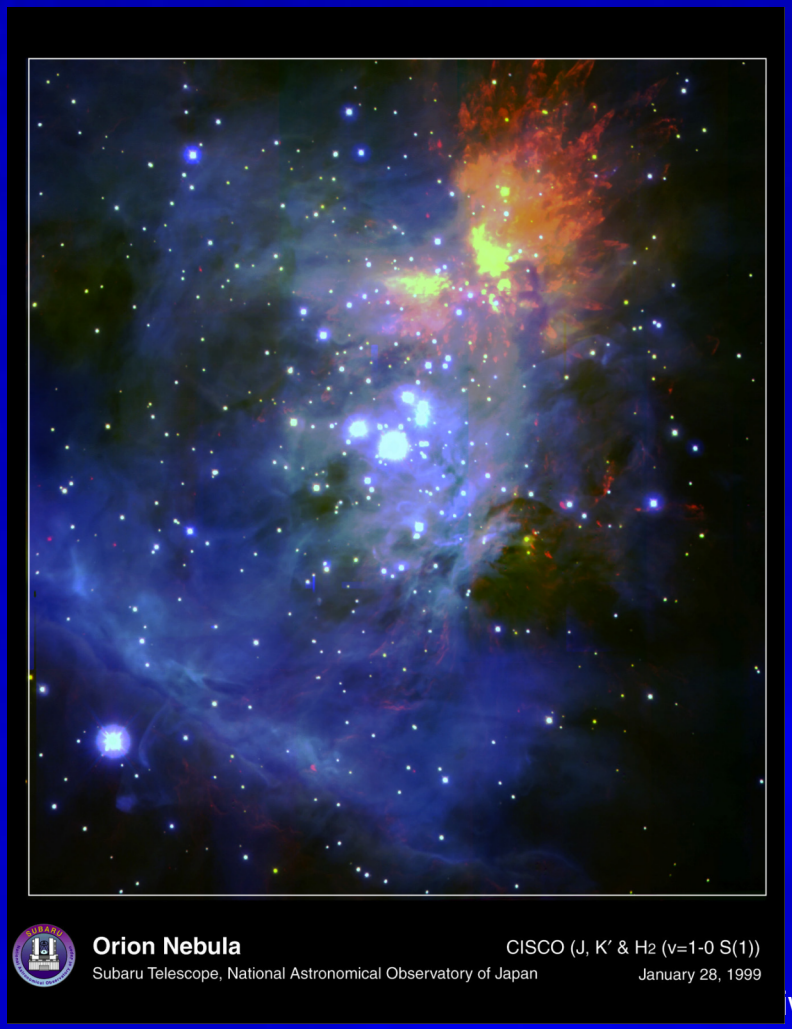
$M_{planet} / M_{star} = 0.5\ M_{Jup} / 1\ M_{sun}$

Orbital radius: 5 AU

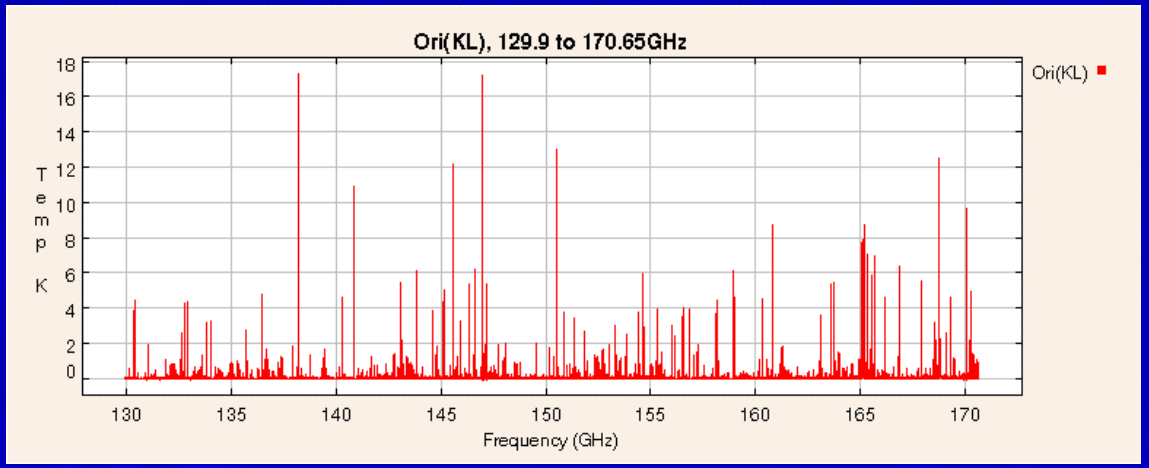
Disk mass as in the circumstellar disk around the Butterfly Star in Taurus

(ALMA: 10km, t_{int}=8h, 30° phase noise)
Wolf & D'Angelo (2005)

ALMA Key Science 2: Astrochemistry



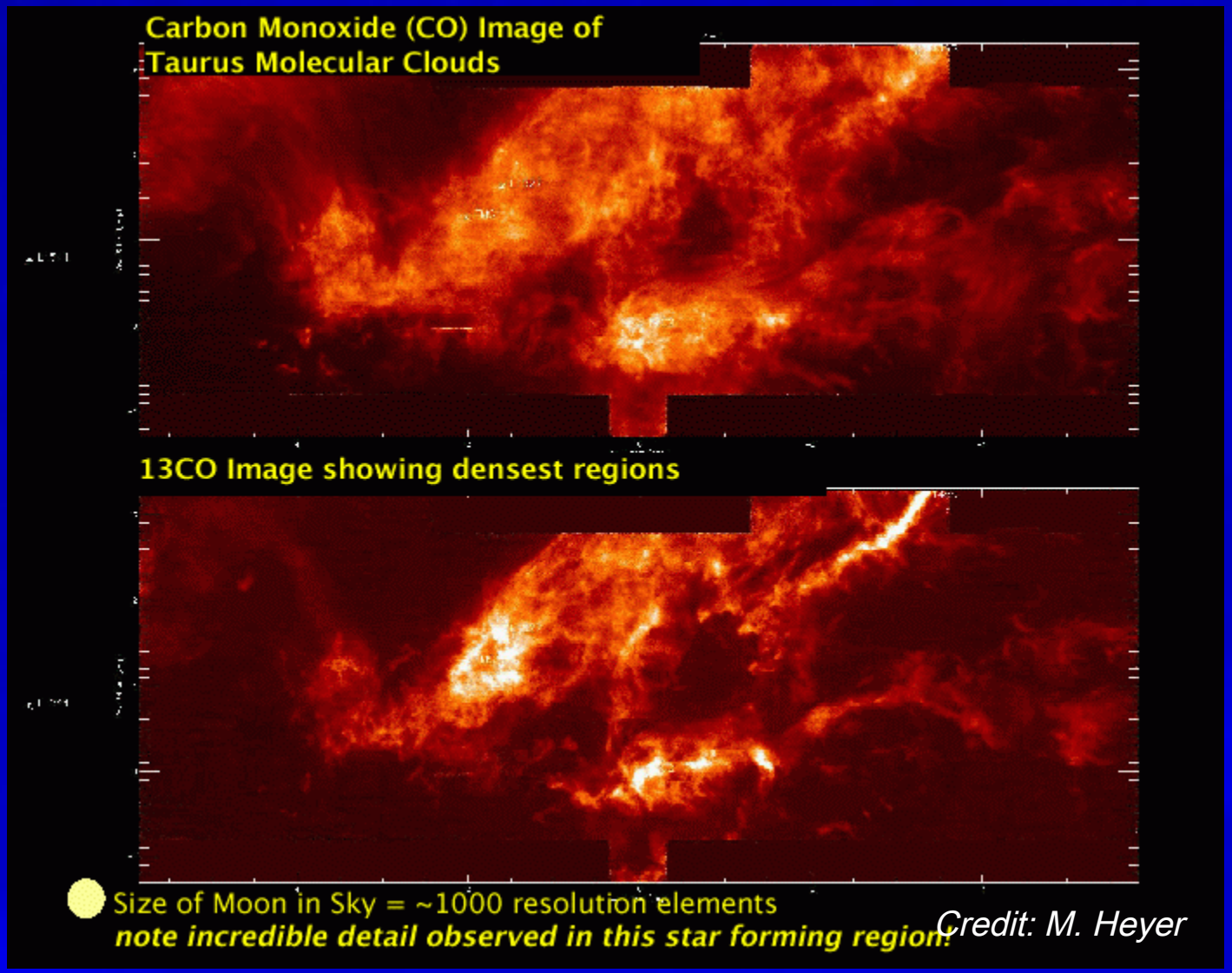
Spectrum courtesy B. Turner (NRAO)



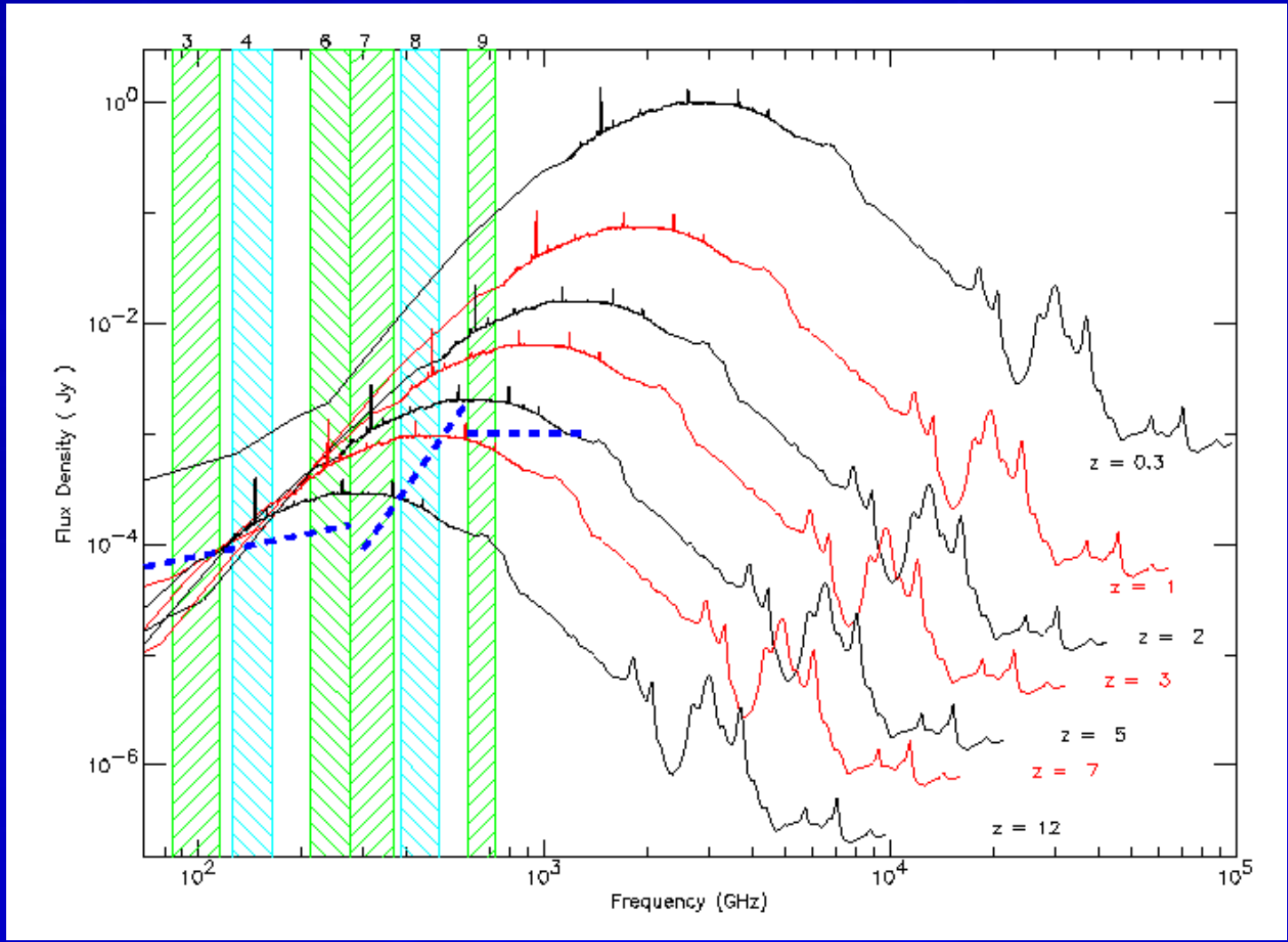
- Millimeter/submillimeter spectral components dominate the spectrum of planets, young stars, many distant galaxies.

- Most of the observed transitions of the 125 known interstellar molecules lie in the mm/submm spectral region—here some 17,000 lines are seen in a small portion of the spectrum at 2mm.

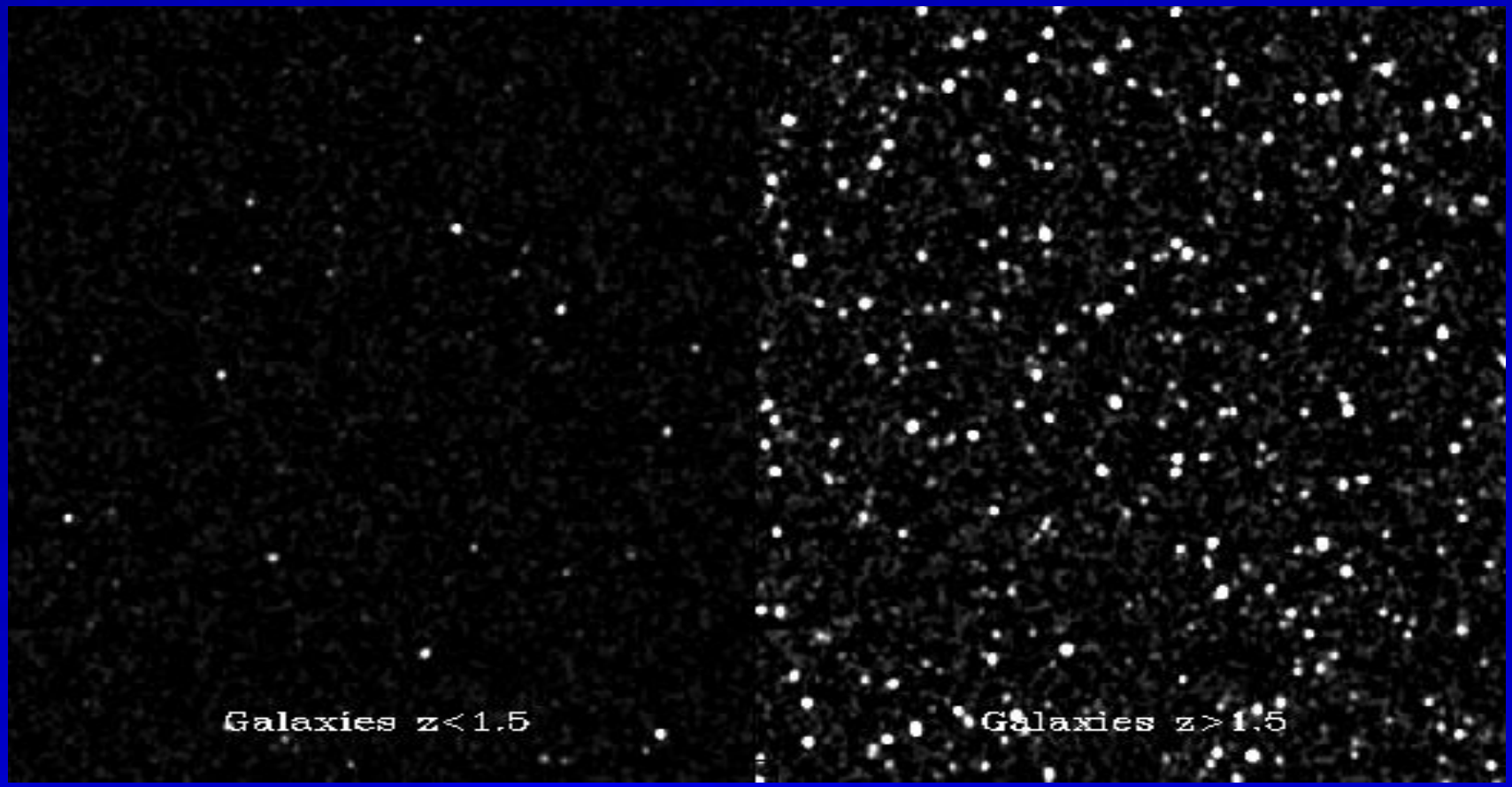
ALMA Key Science 3: Interstellar Medium



ALMA Key Science 4: High redshift galaxies



ALMA Deep Field: Rich in Distant Galaxies



Nearby galaxies in ALMA DF

Distant galaxies in ALMA DF

ALMA Specifications

- 54 12-m antennas, 12 7-m antennas, at 5000m site
- Surface accuracy <25 mm, 0.6” reference pointing in 9m/s wind, 2” absolute pointing all-sky.
- Array configurations between 150m and ~15-18km.
- Angular resolutions ~40mas at 100 GHz (5mas at 900GHz)
- 10 bands in 31-950 GHz + 183 GHz WVR.
- 8 GHz BW, dual polarization.
- Interferometry, mosaicing & total-power observing.
- Correlator: 4096 channels/IF (multi-IF), full Stokes.
- Data rate: 6MB/s average; peak 64 MB/s.
- All data archived (raw + images), pipeline processing.

ALMA Site

ALMA

Paranal

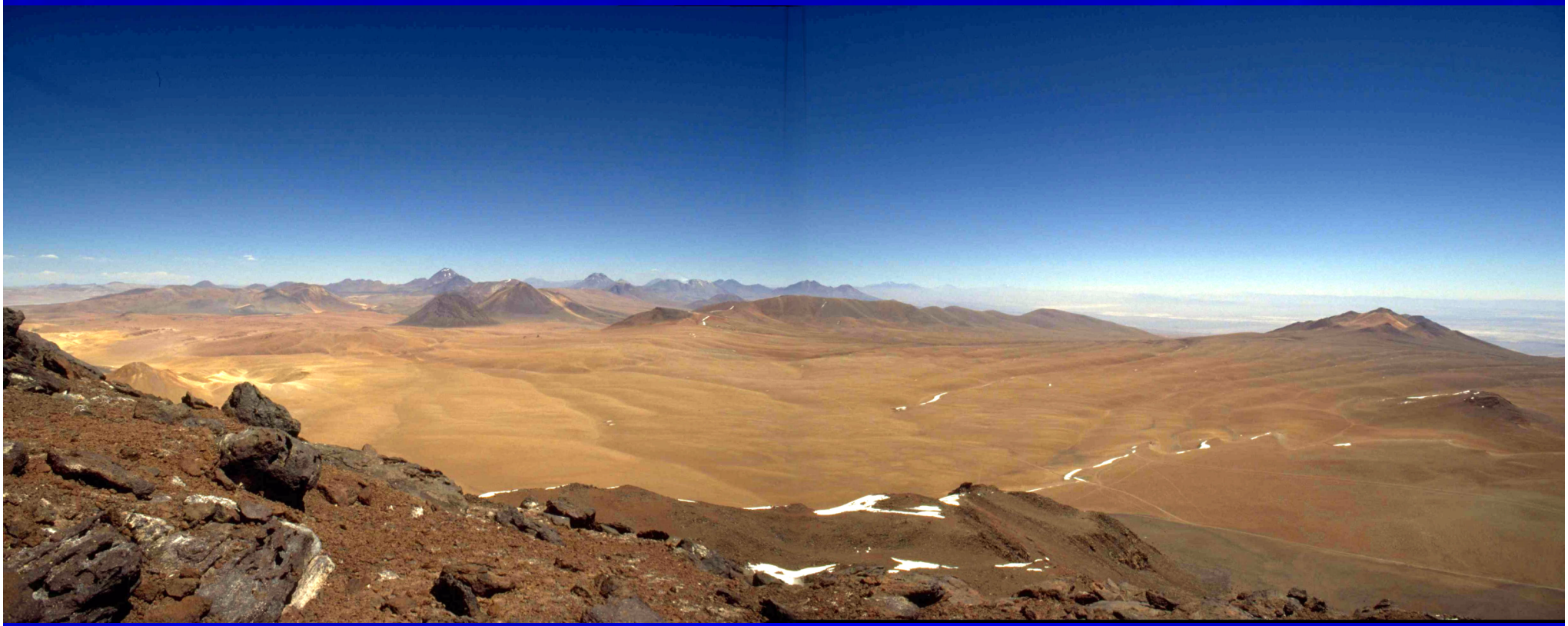
La Serena

Santiago


San Pedro de Atacama,
Atacama Desert, Northern Chile


ALMA Sites
To Array Operation Site (43km)
Operations Support Facility Site (15km)
PARE
60
PELIGRO
Oct 2007

5000m Chajnantor plateau – looking south
Array Operations Site



Chajnantor Plateau – looking north

AOS Technical Building

(Correlator, offices, guards, emergency facilities)

The ALMA Transporter – Rear View

ESO Press Photo 32e/07 (30 July 2007)

The ALMA Transporter

ESO Press Photo 32b/07 (30 July 2007)

Transporter in Germany, July 2007

Vertex #1 in Antofagasta - April 2007

3 ACA 12-m antennas en route to OSF

(15 km/hr for 3 days)

Vertex Antenna Arrival

MEICo Camp

Three 12m and one 7m antennas

AEM Antenna Assembly at the OSF

Teams Trained for Panel Setting

DV01 makes the climb from the OSF to the AOS (2009)

Correlator First Quadrant at AOS

3 Long Baselines (Feb 2010)

Third antenna joins the Compact Array on April 1, 2010

7 Antennas on the Compact Array stations

September 2010,
8 Antennas working together

December 13, 2010 - 9 antennas

Phase 2 cluster + one Phase 1 location providing long baselines for testing

Current Shape of the OSF

Seen from the holography tower

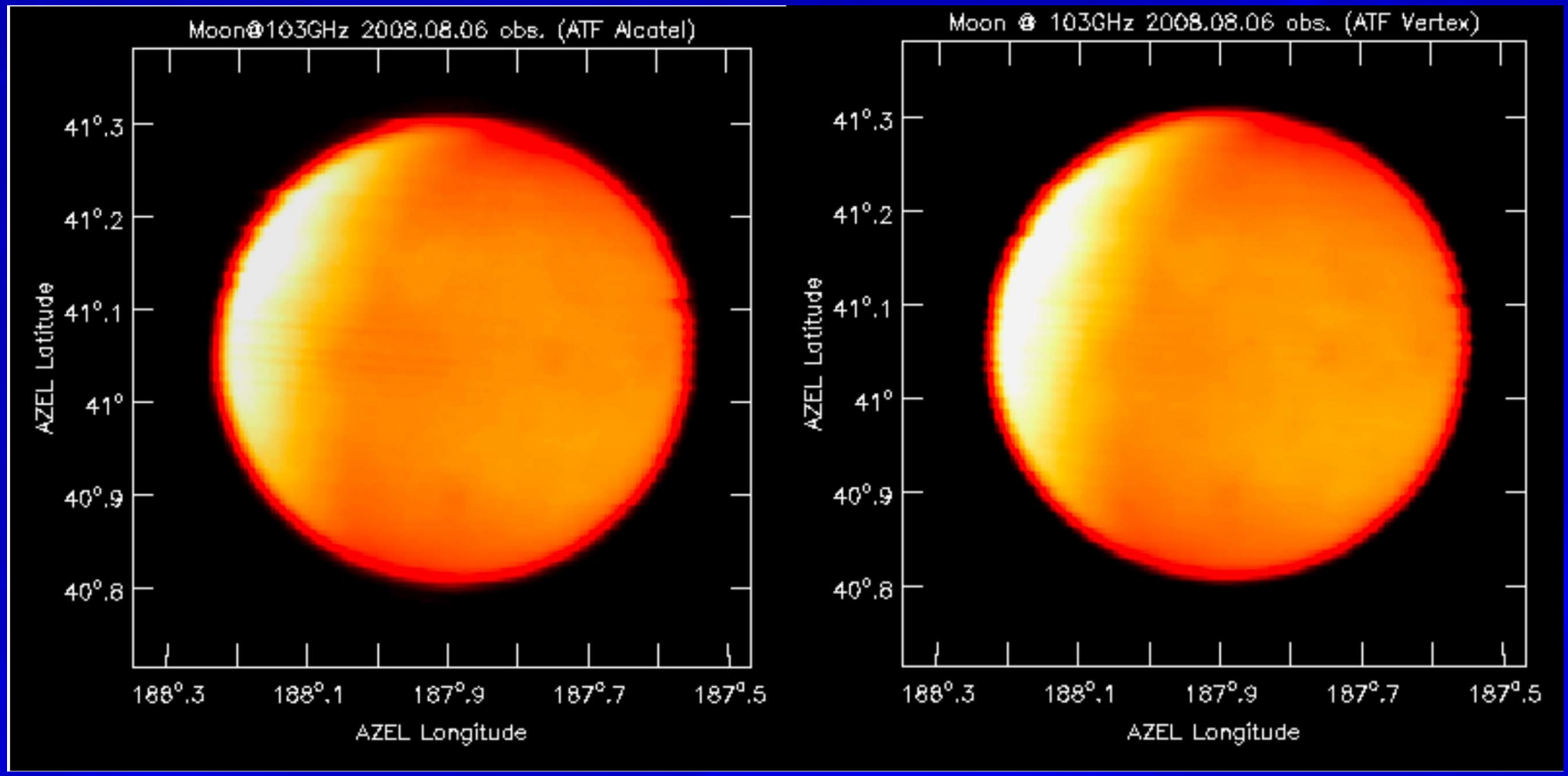
All Testing Stations at the OSF are now occupied - May 2011

May 2011 - 14 antennas at the AOS!

Control Room - OSF
(evening shift)

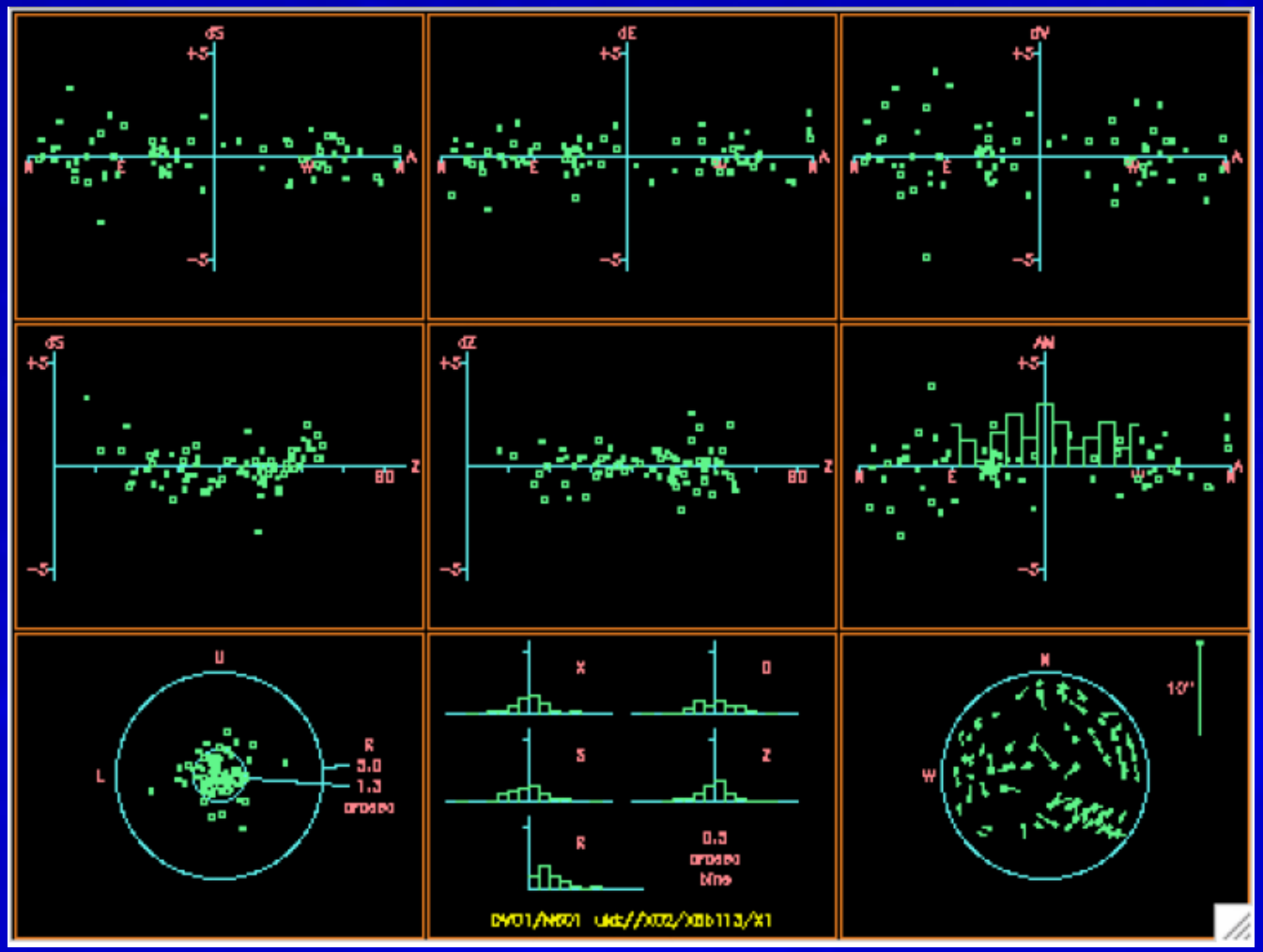
Single Dish On-the-Fly Mapping

Early e2e software test, Moon with 2 antennas simultaneously



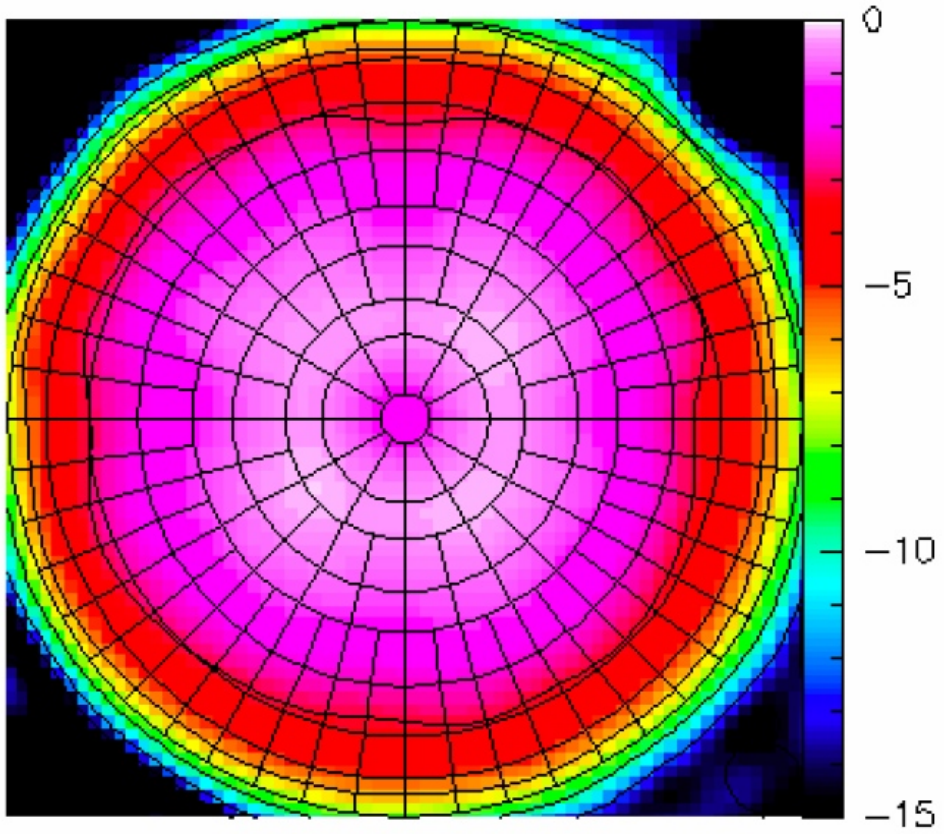
Pointing Monitoring

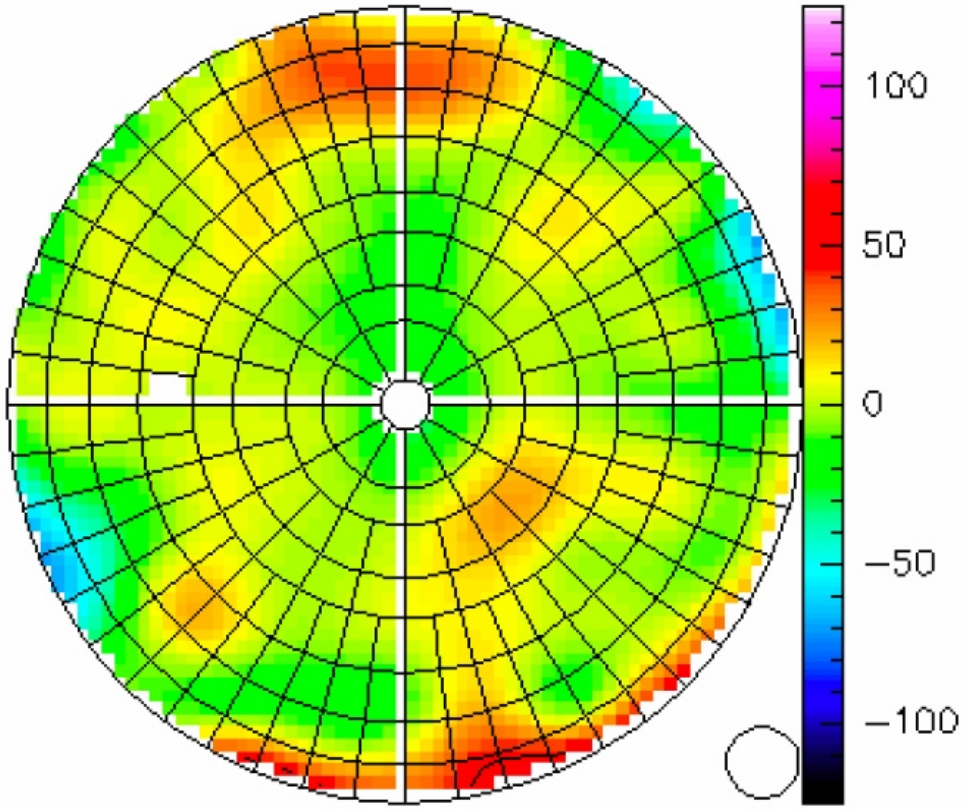
DV01
rms=1.8”



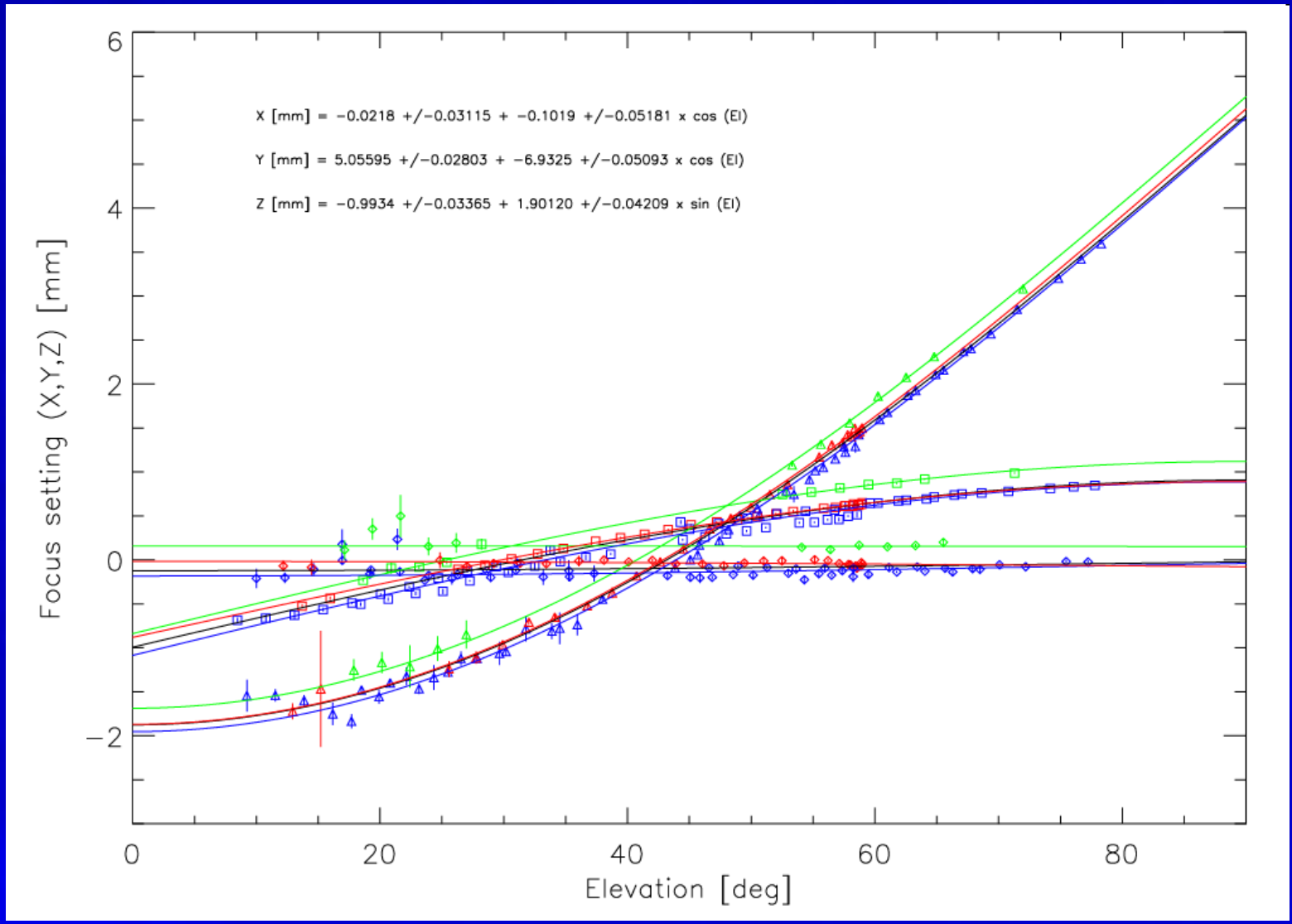
Astronomical Holography

3C279 at high elevation



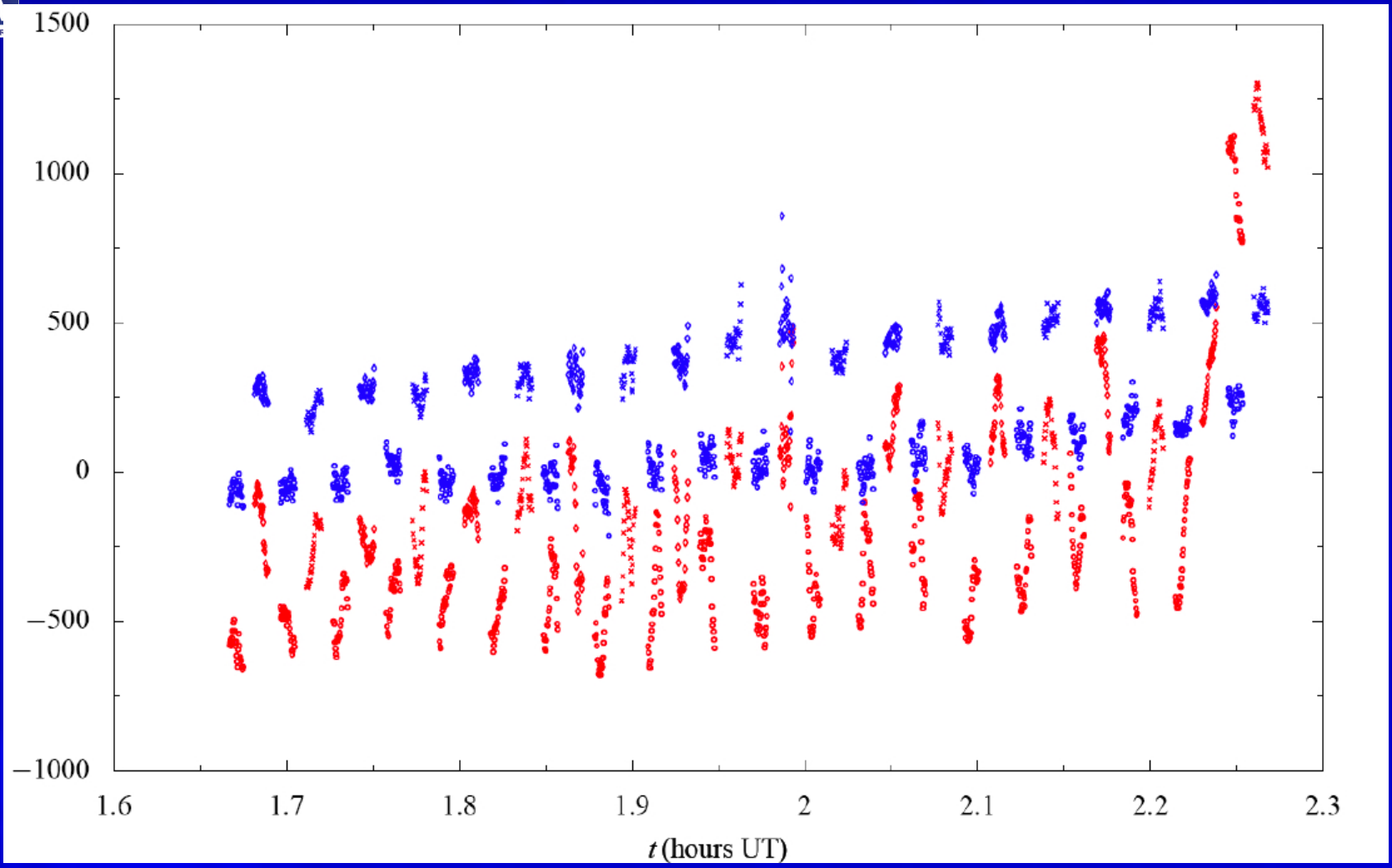


Measuring Focus Curves



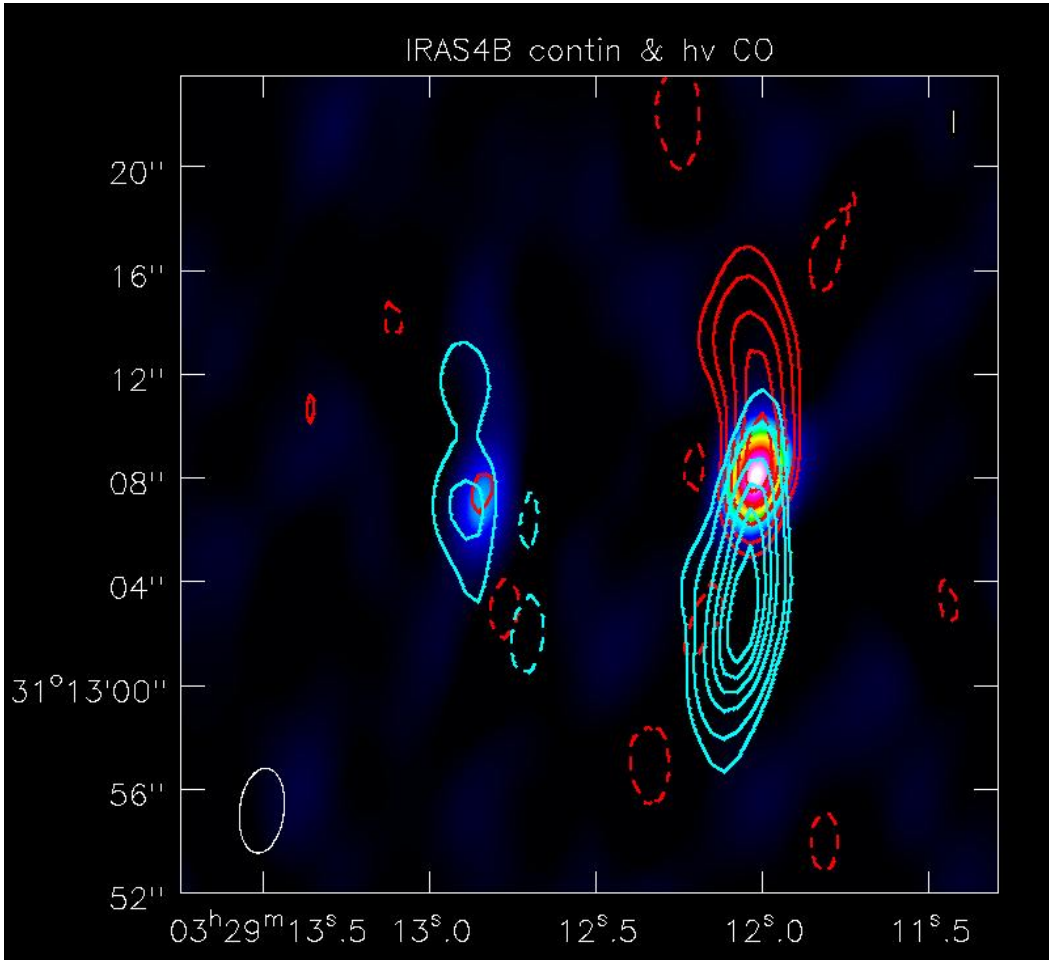
Water Vapor Correction

Cycling between 3C273, 3C279, Pluto; blue=corrected



Molecular Outflows from Low Mass Protostars: IRAS 4B

ALMA

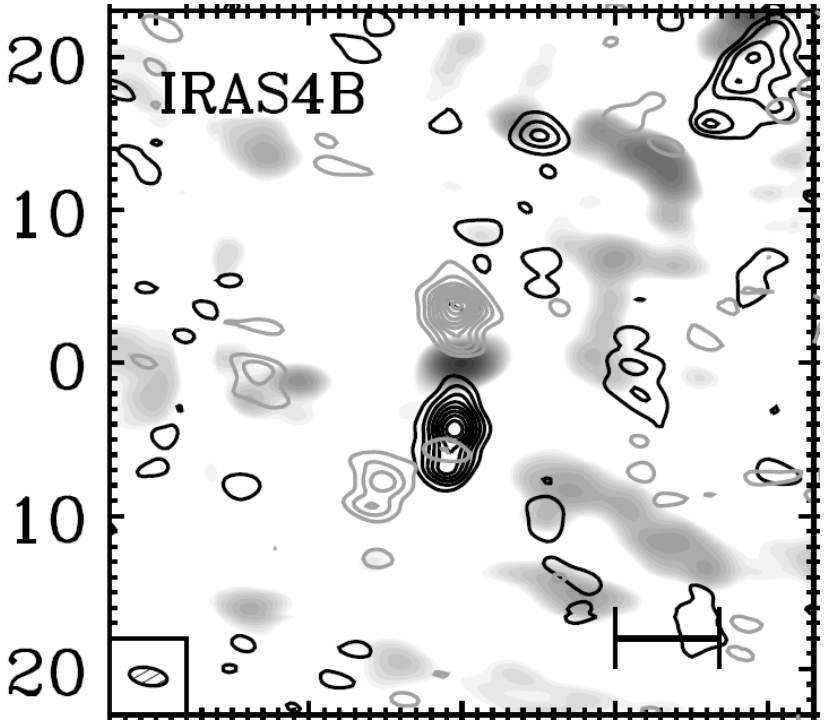


Observed on September 16
7 antennas, 2 hours, band 7, high-velocity CO + SO + continuum emission

NGC1333 IRAS4B, band 7

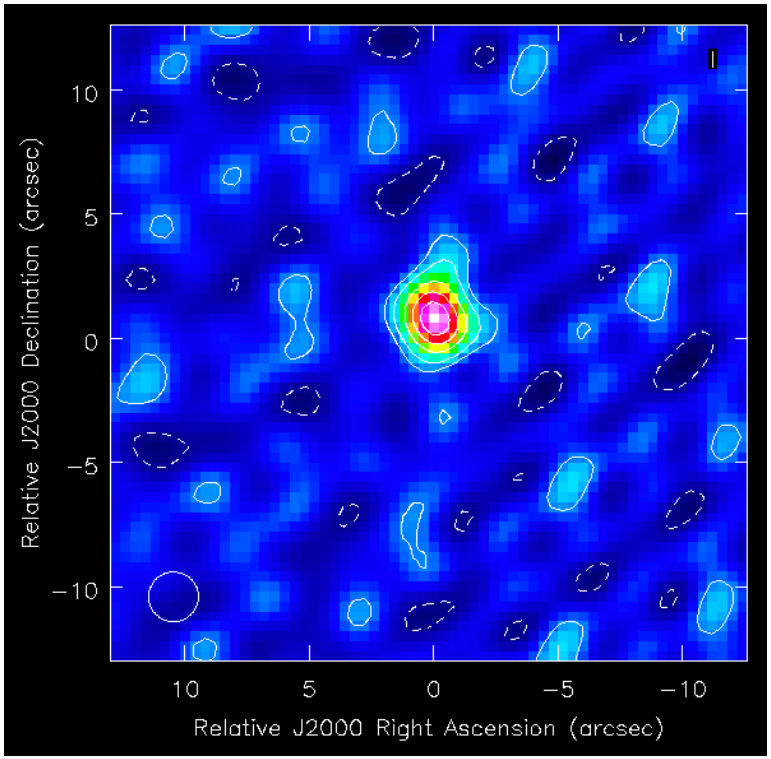
SMA, 230 GHz, high-velocity CO + continuum emission

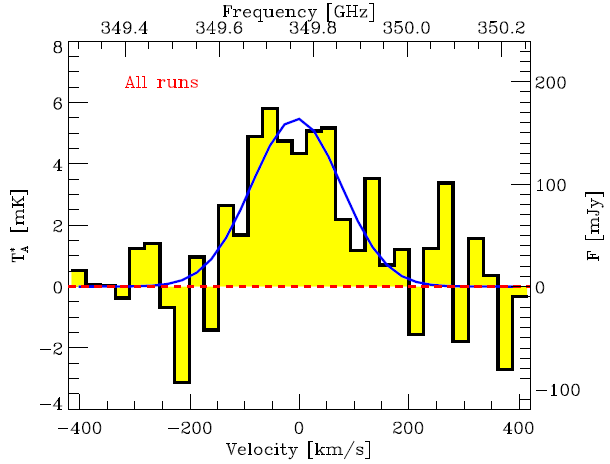
Jorgensen 2007



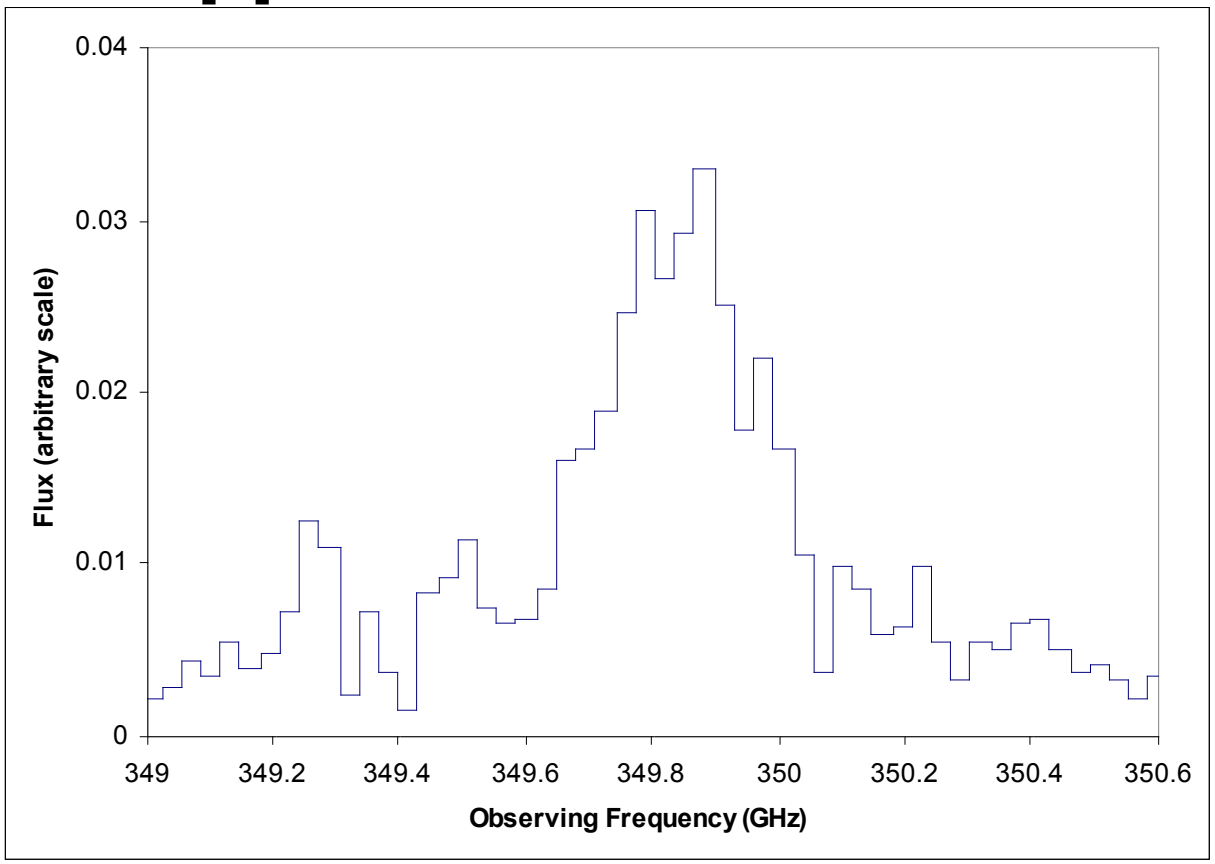
High Redshift Line Sources

ALMA





C[II] line in BRI 0952 at *z*=4.4



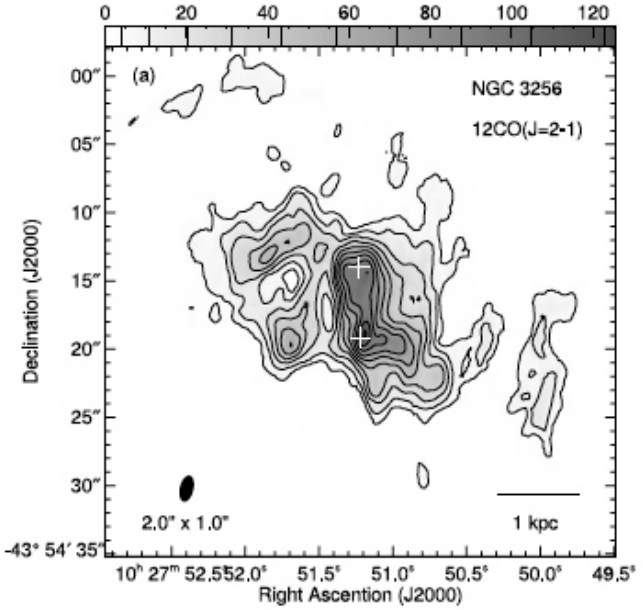
Band 7 16th Nov 2010 ↑ 8 Antennas, 1 hour

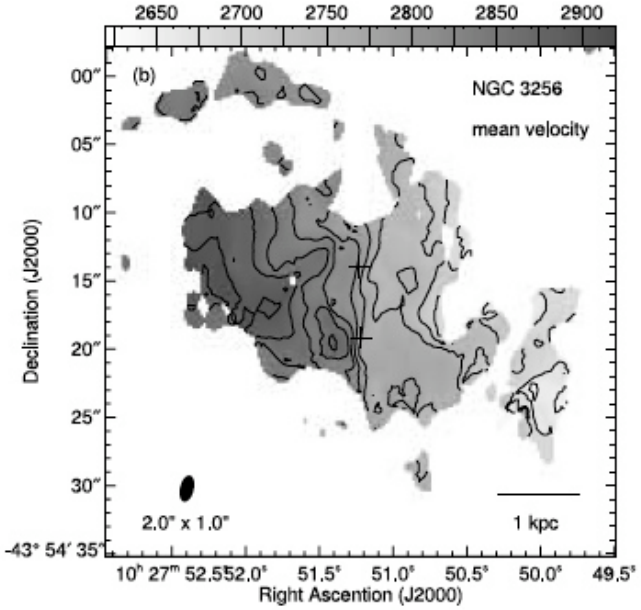
← APEX

NGC 3256

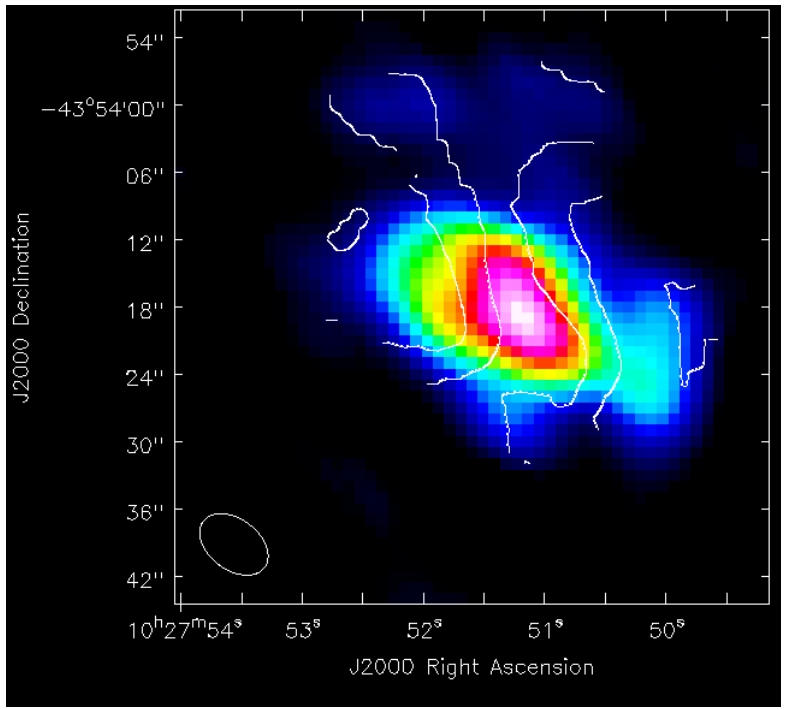
Gas-rich galaxy
Structure on left
Velocity on right

- SMA data
-
- ALMA data
- 8 Antennas, 4 hours

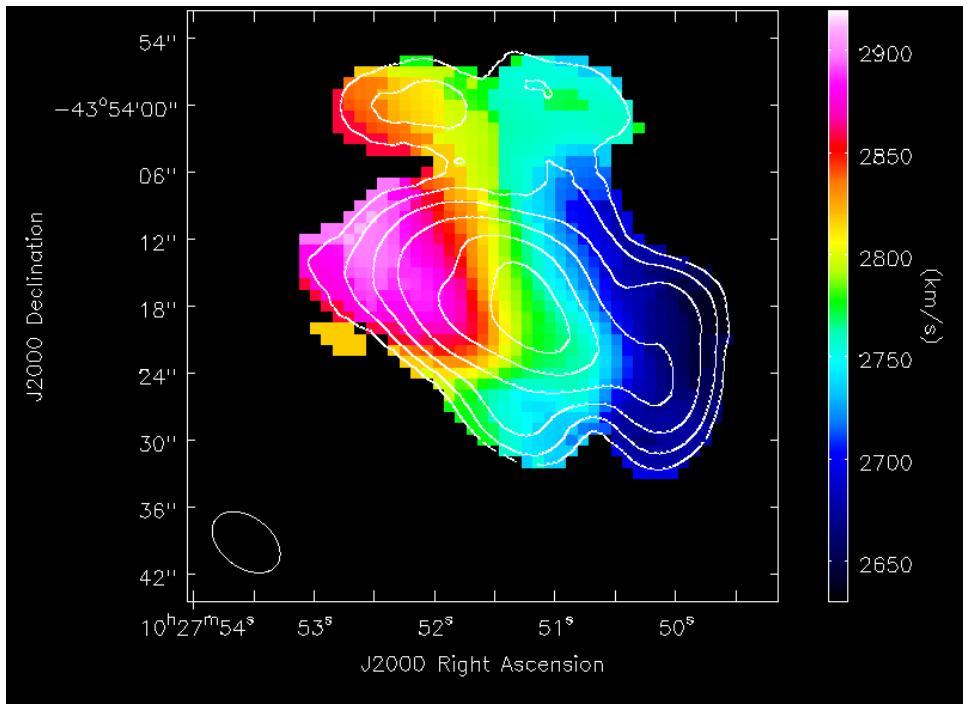




CO (1-0) *Integrated Intensity*



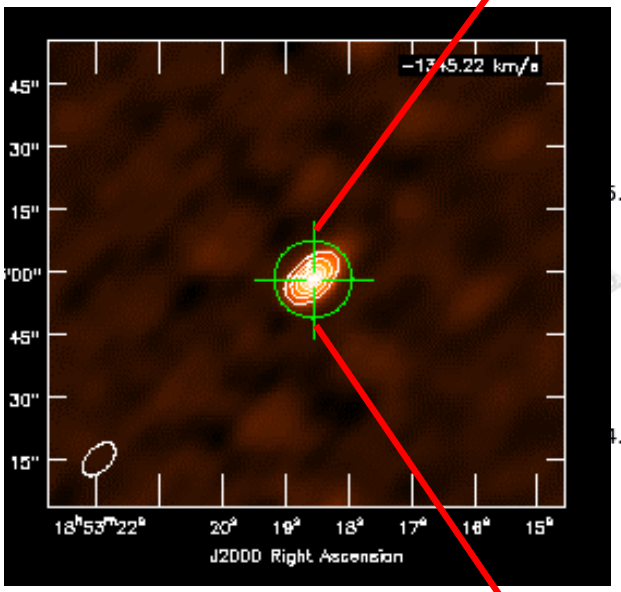
Velocity field

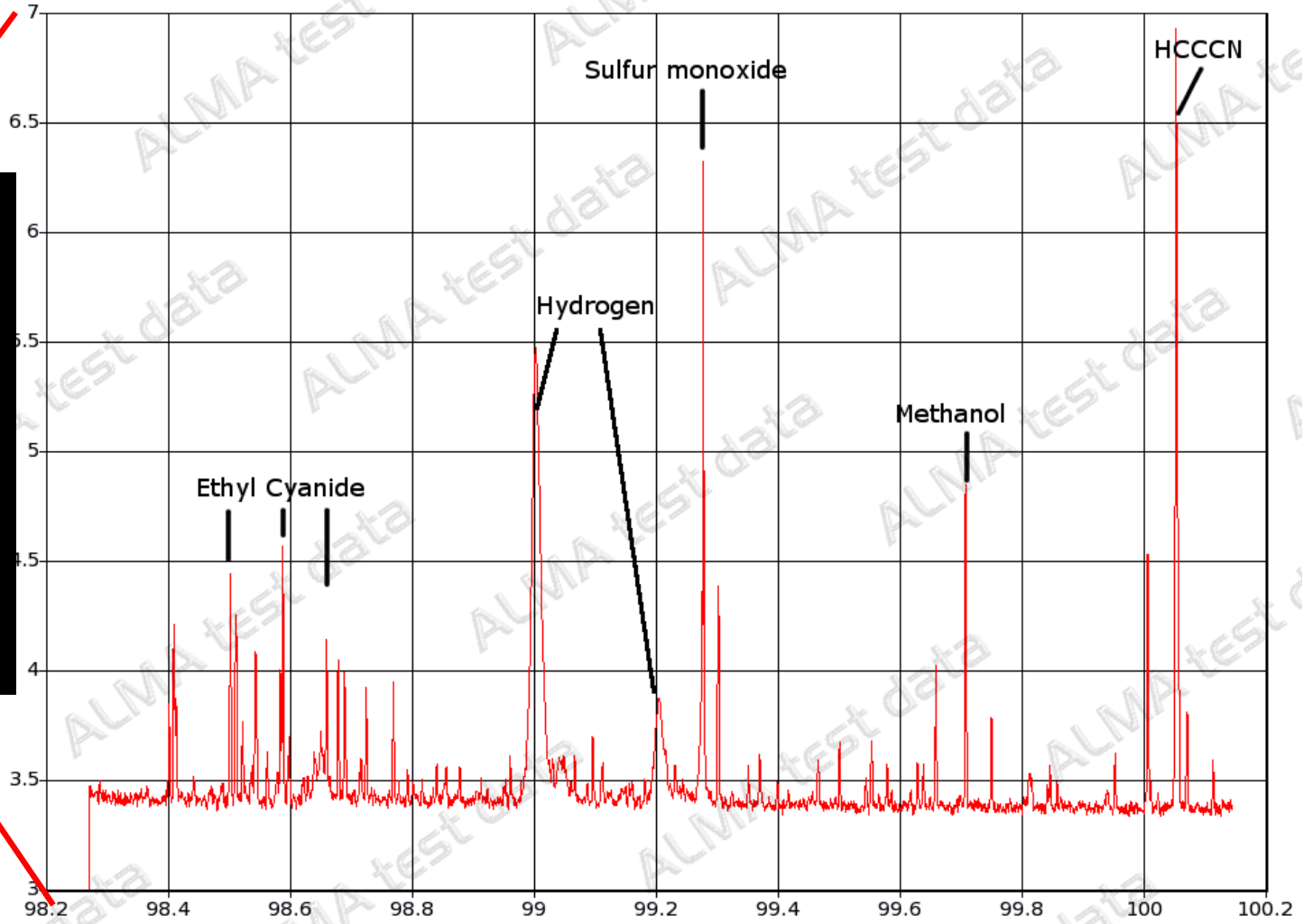


High Mass Star Formation:
G34.26+0.15 “Hot Core”

ALMA

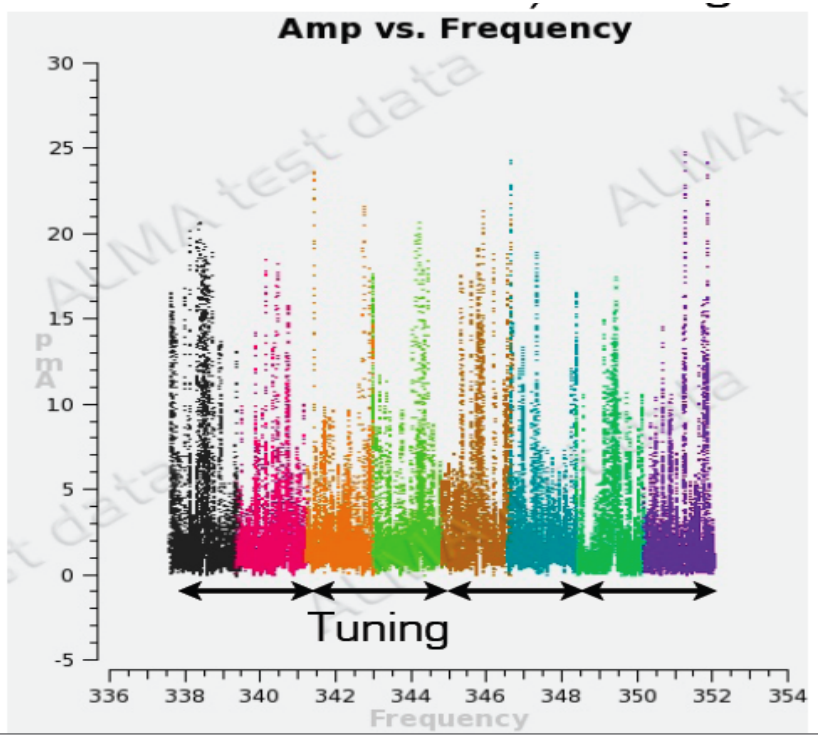
Band 3 Single 2 GHz Spectral Window





7 antennas, 2.5 hours observations

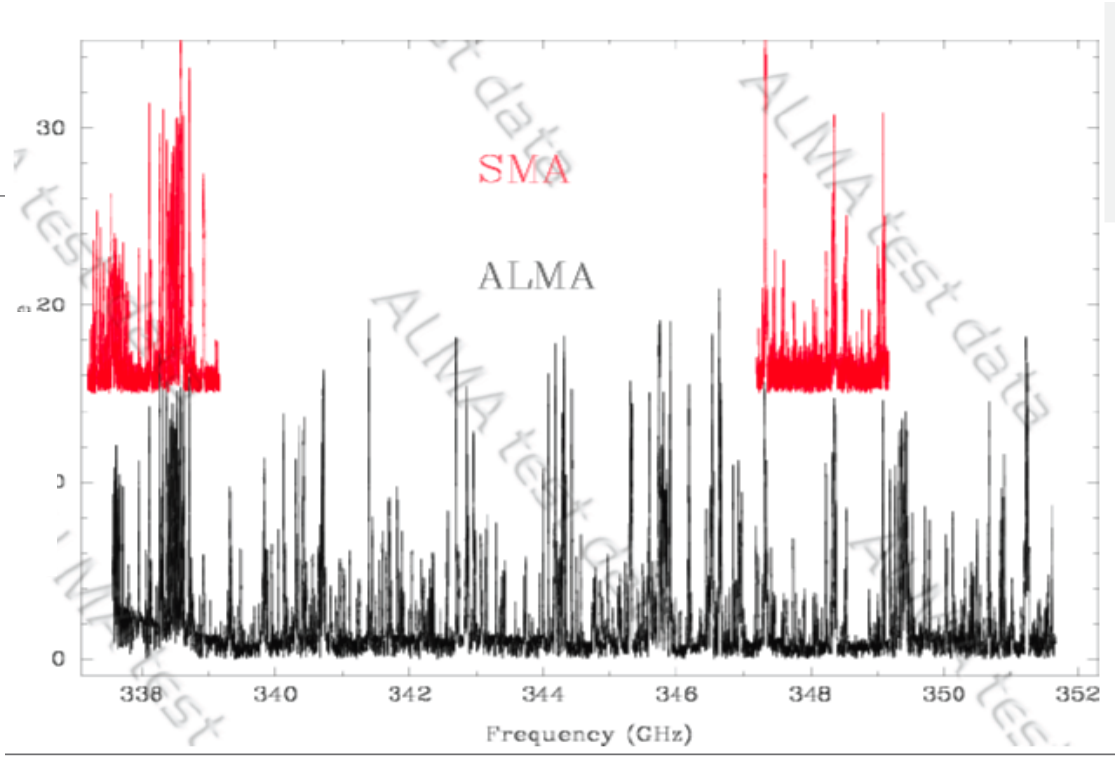
Orion Spectral Sweep



- *4 Tunings*
- *Total Bandwidth 14.7 GHz*
- *14 min. on source per tuning*

Red=SMA (Beuther et al.)

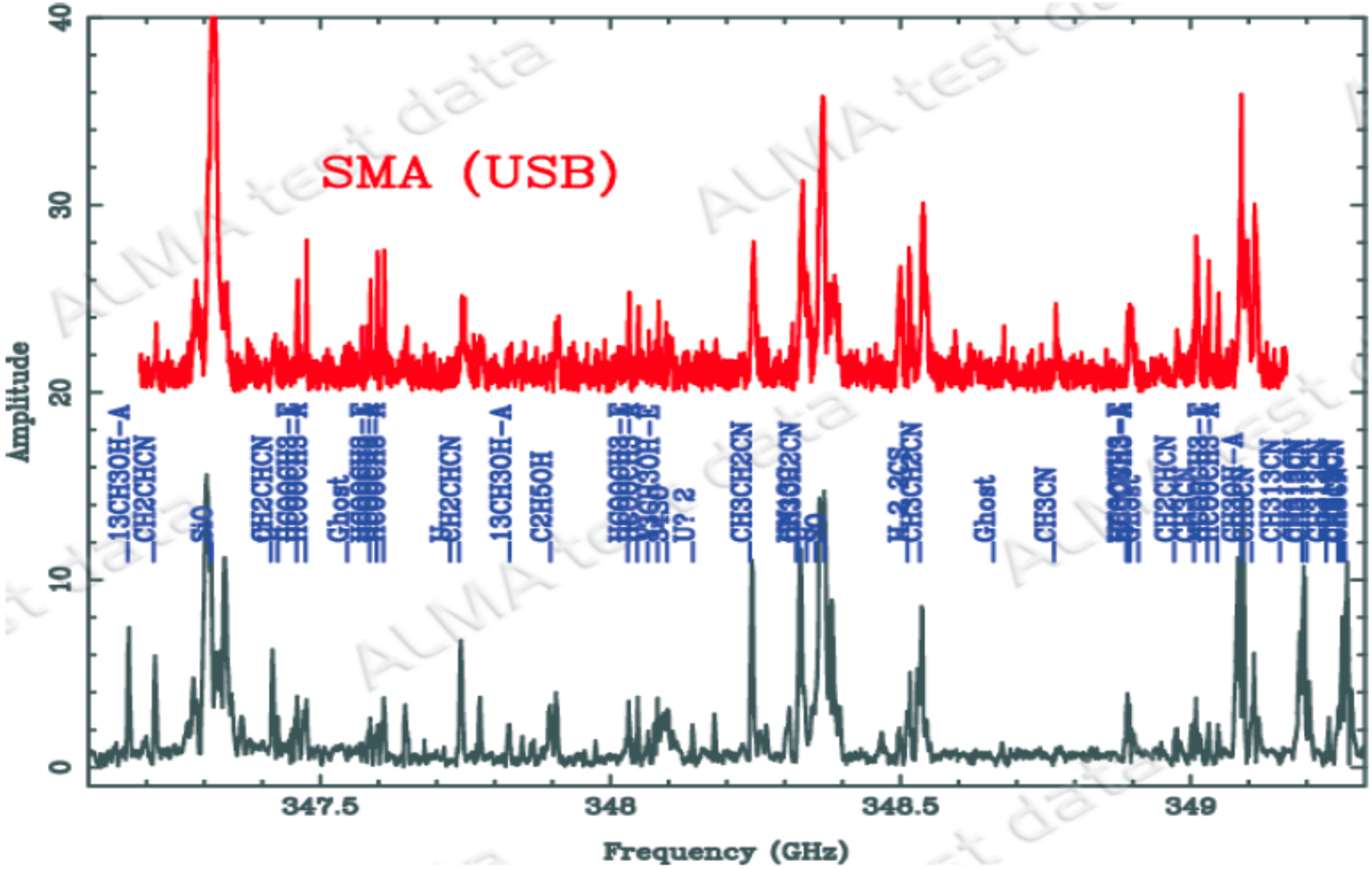
Black=ALMA



Zoom on Orion Spectral Sweep

Red=SMA (Beuther et al.)

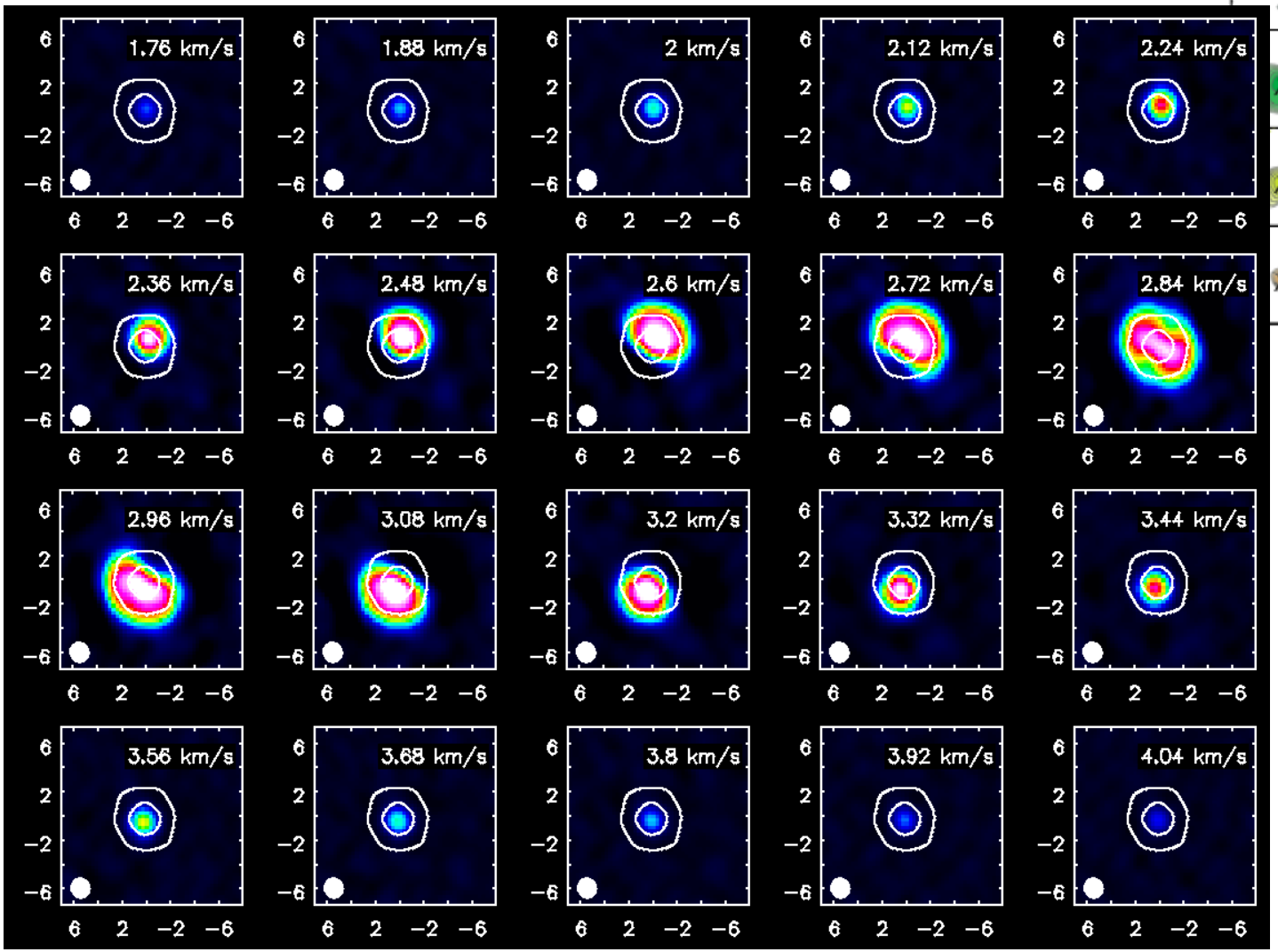
Black=ALMA

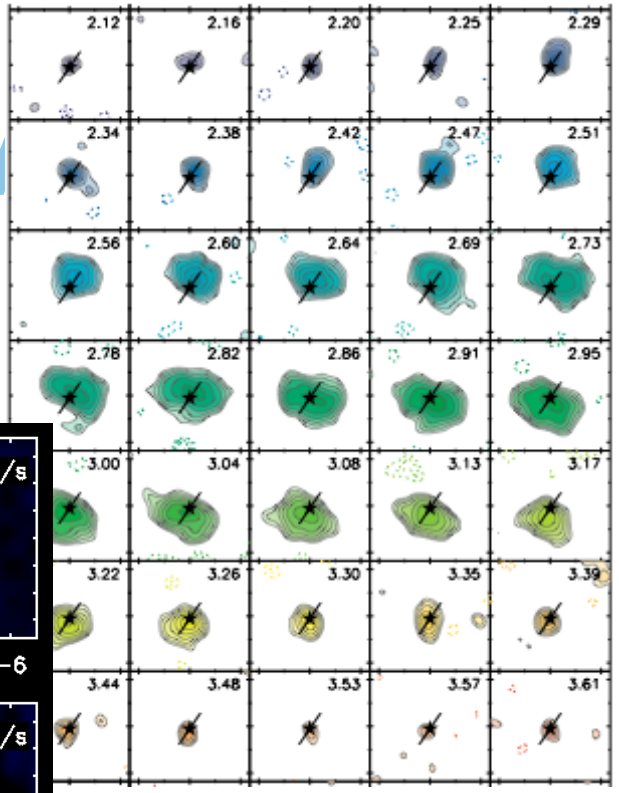


TW Hydra – Protoplanetary Disk

Channel Maps of CO(3-2)

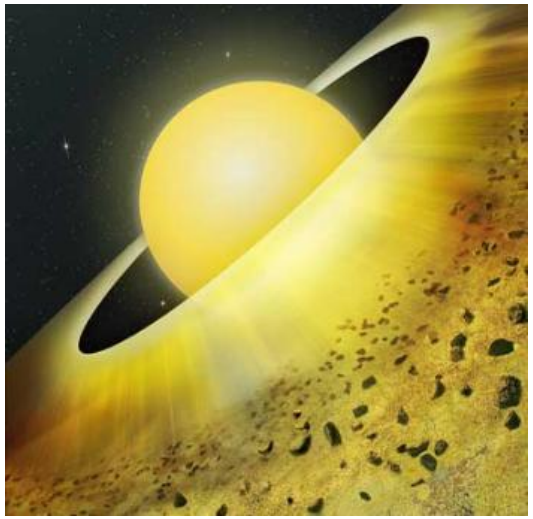
ALMA (8 antennas, 4.5 hours)





SMA 2 tracks

(Hughes et al. 2011)

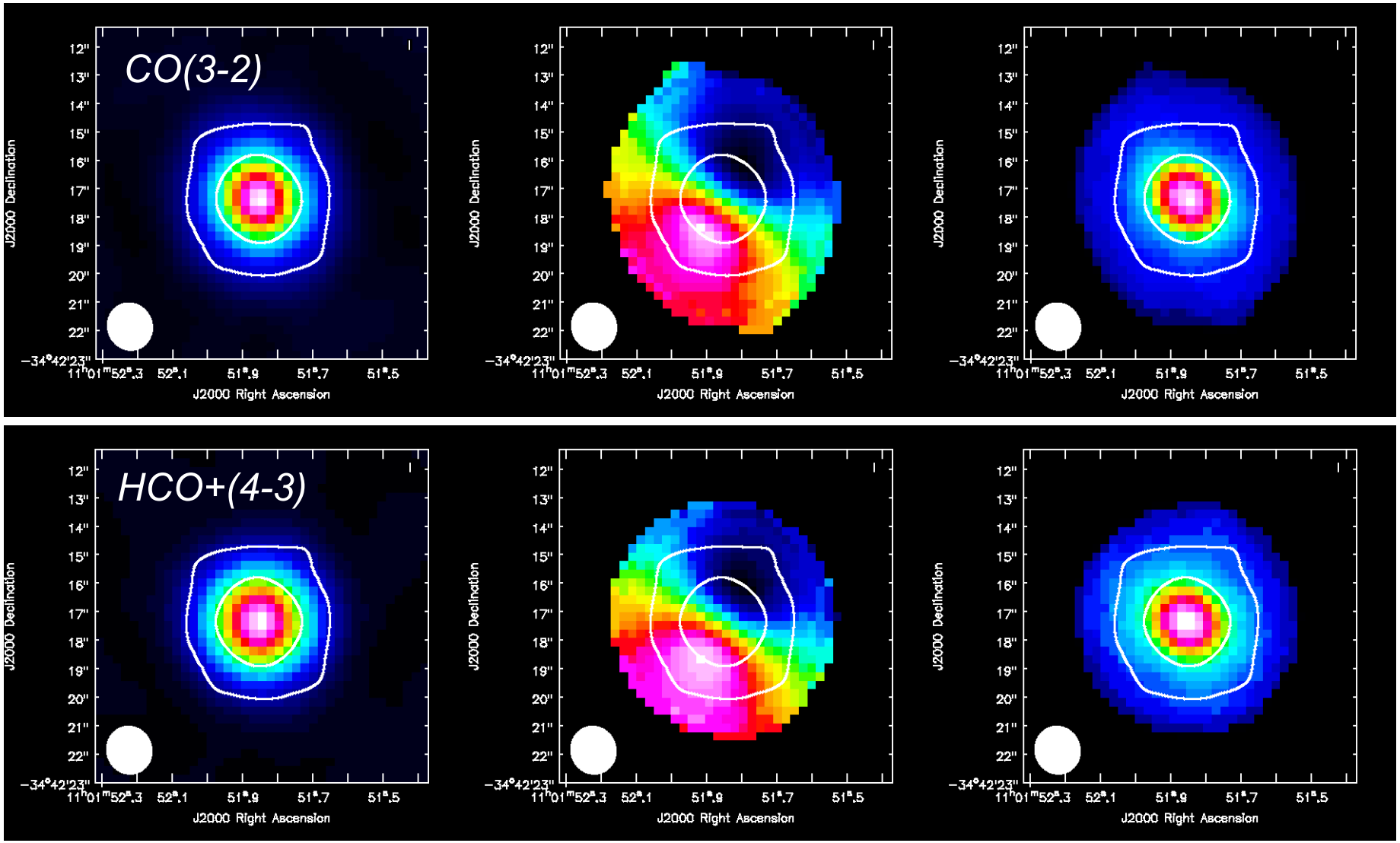


TW Hydra – Protoplanetary Disk

Moment Maps of CO(3-2) and HCO+(4-3)

ALMA

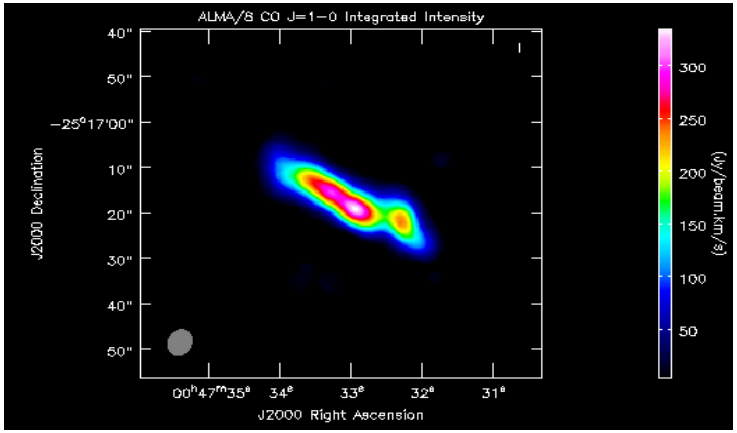
- Molecular emission is quite extended, Keplerian motion obvious
- HCO+(4-3) is more centrally concentrated than the CO(3-2)



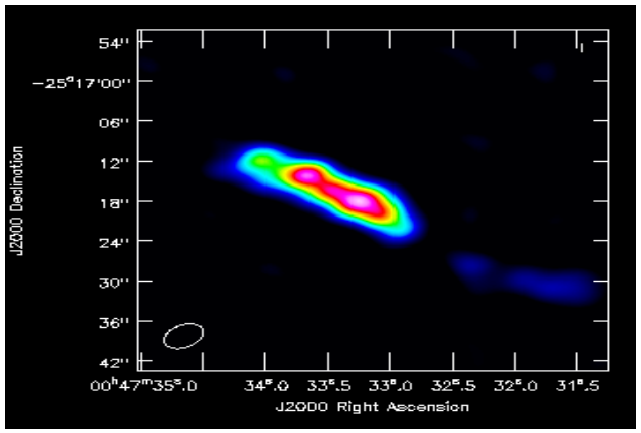
NGC253: a "starburst" galaxy in 4 transitions

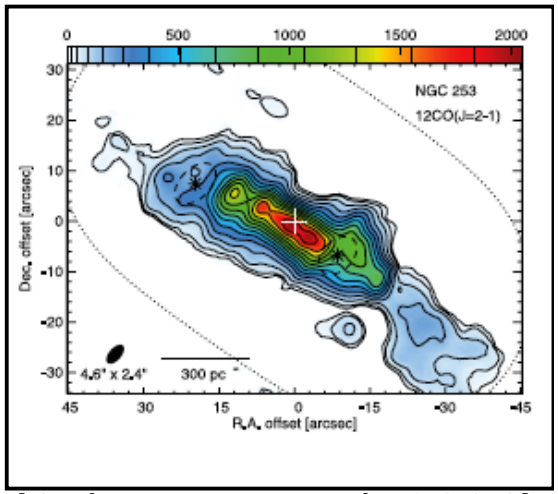
ALMA

NGC 253 – B3 – CO J=1-0



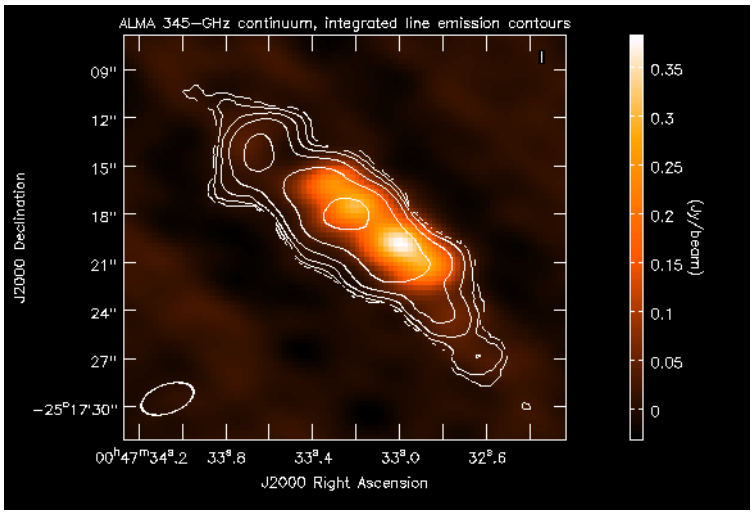
NGC 253 – B6 – CO J=2-1



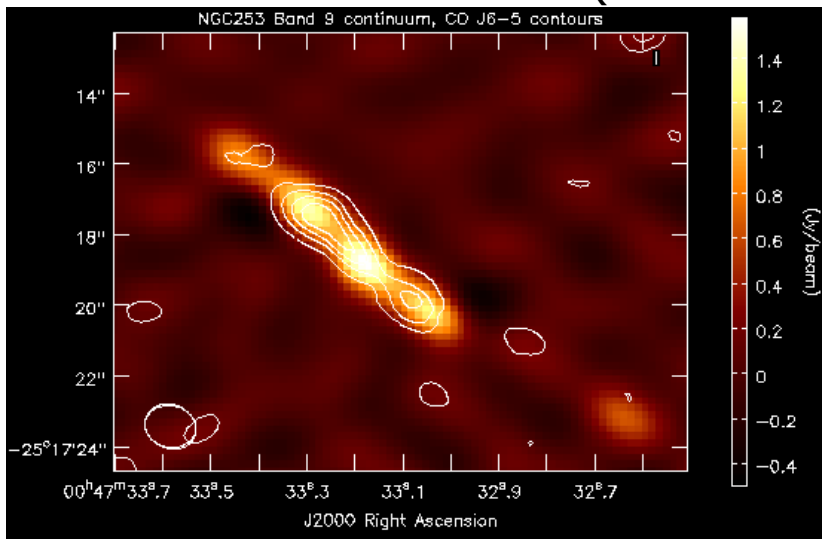


(Sakamoto et al, 2006)

NGC 253 – B7 – CO=3-2



NGC 253 – B9 – CO=6-5



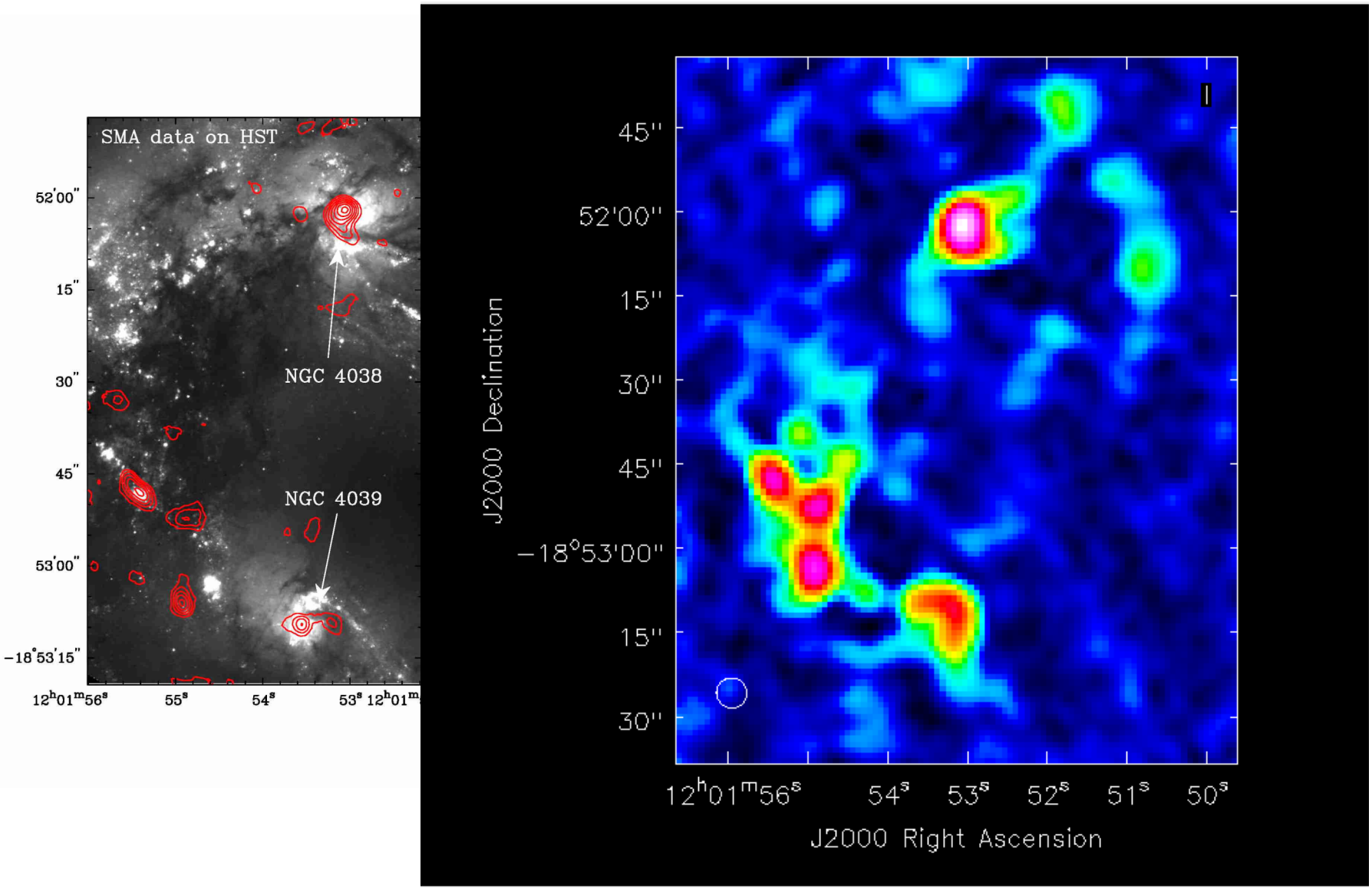
Band 3 → 2 nights, 5&8 antennas, 10 hours
Band 7 → 7 antennas, 7 hours

Band 6 → 7 antennas, 12 hours
Band 9 → 4 antennas, 6 hours

Antennae Galaxies (NGC4038/9)

ALMA

Preliminary results of mosaic observations of CO (1-0)



For more info:

http://www.almaobservatory.org

The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile. ALMA is funded in Europe by the European Organization for Astronomical Research in the Southern Hemisphere (ESO), in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC) and in East Asia by the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Academia Sinica (AS) in Taiwan. ALMA construction and operations are led on behalf of Europe by ESO, on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI) and on behalf of East Asia by the National Astronomical Observatory of Japan (NAOJ). The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction, commissioning and operation of ALMA.