

# ALMA Science Verification Program

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EUROPEAN ARC  
ALMA Regional Centre

# Science Verification

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- The process by which ALMA demonstrates that it is capable of producing data of the required quality
- So far focused on reproducing results already obtained with other telescopes
- The reduced and calibrated datasets will be available to the community for download
  - raw data
  - data reduction scripts and CASA guides
  - data products: images, cubes



# SV data available

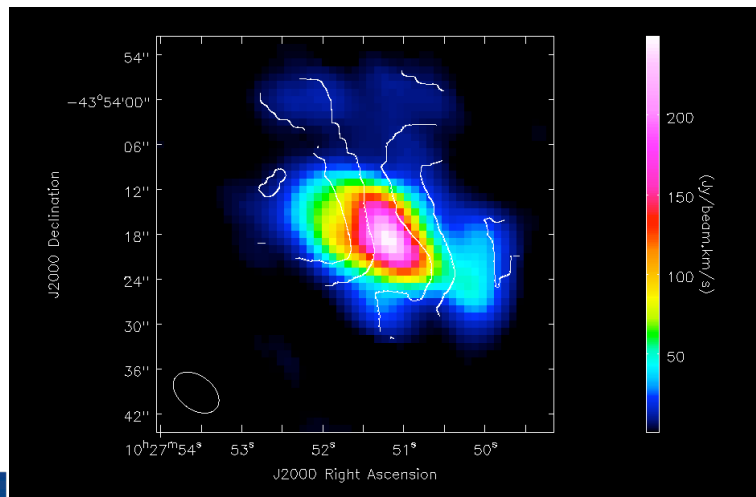
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- TW Hya: Band 3, 6, 7, high spectral resolution. **Band 7 CASA guide**
- NGC 3256: Band 3, low spectral resolution. **Band 3 CASA guide**
- Antennae galaxies: Band 6, 7, high spectral resolution. **Band 7 CASA guide**
- M100 Band 3, low spectral resolution.
- SgrA\* Band 6, recombination lines.
- BR1202-0725 Band 7: low spectral resolution.
- IRAS16293 Band 6 and 9 : high spectral resolution. **Band 9 CASA guide**
- Centaurus A Band 6: high spectral resolution mosaic.
- Orion KL Band 6: high resolution spectral survey.

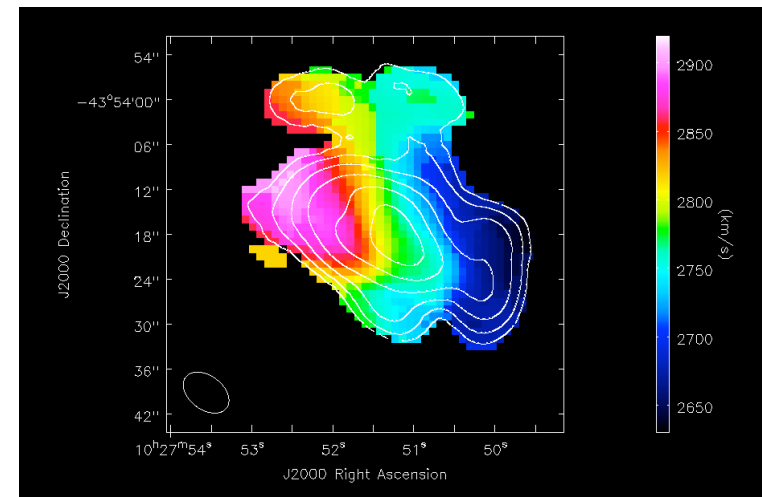


# ALMA Science Verification: NGC 3256

- Band 3 observations of the CO(1-0) line in NGC 3256
- 8 antennas were used, total integration time ~4hours
- NGC3256 is a very bright infrared galaxy.
- This is a nice data set to test your data reduction skills. The full calibration and imaging can be done on a regular desktop or laptop computer

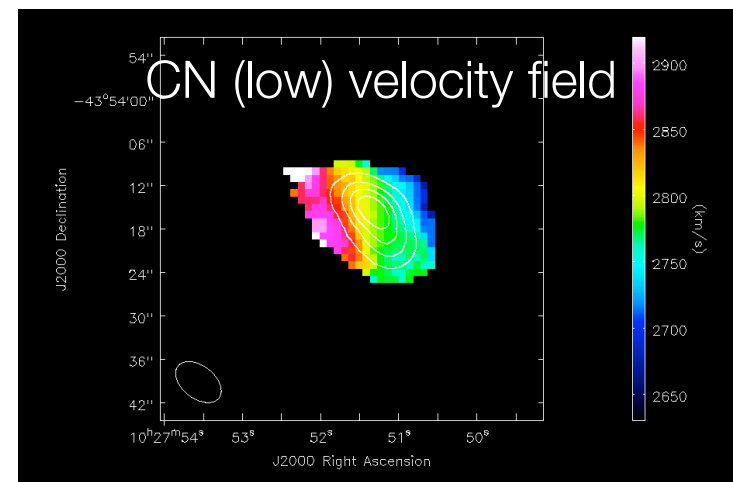
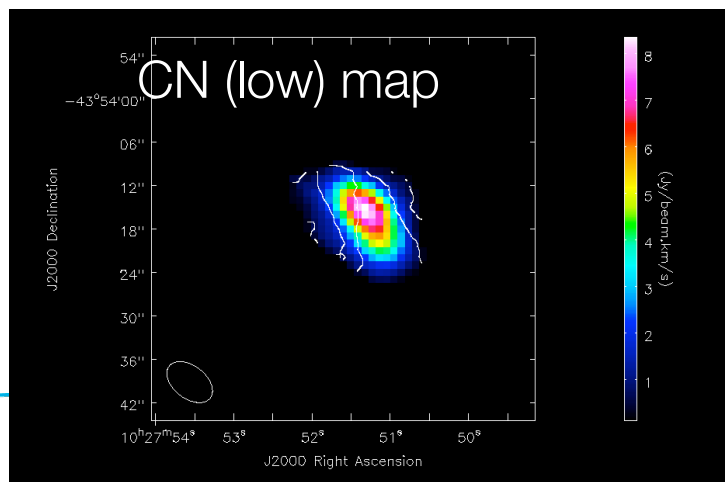
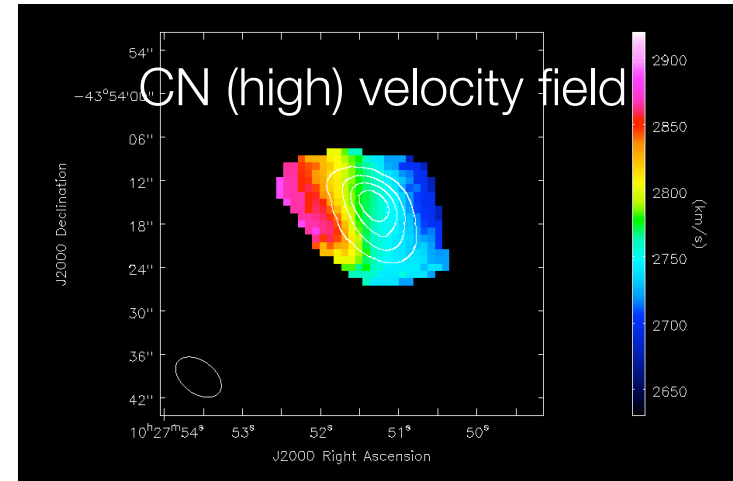
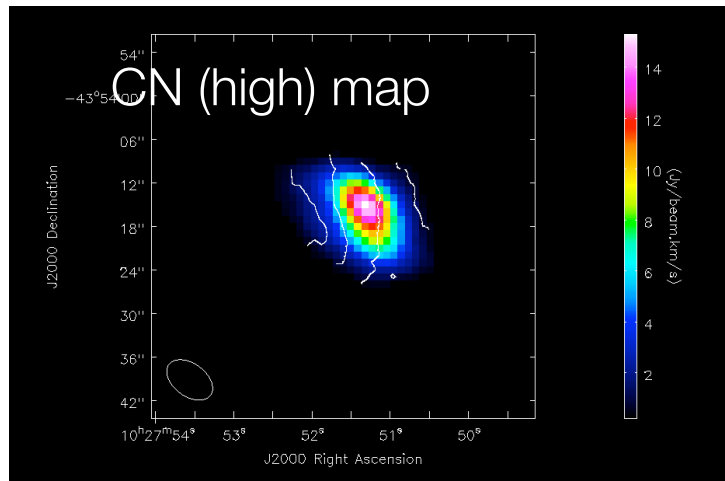


CO(1-0) map



CO(1-0) velocity field

# ALMA Science Verification: NGC 3256



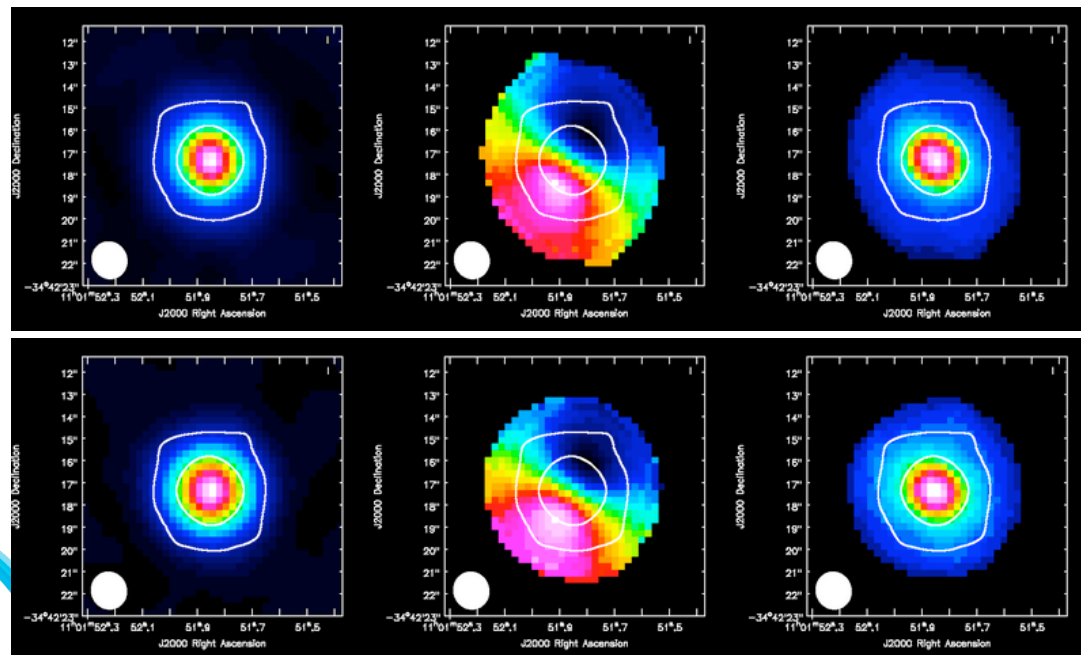
# ALMA Science Verification: TWHya

- TW Hya: classical T Tauri star
  - Age of 10 Myr, Distance  $51 \pm 4$  pc, Actively accreting
- Images at various wavelengths reveal an optically thick dust disk
- Band 7, total time 4.5 hours, 8 antennas

Intensity

Velocity Field

Velocity dispersion

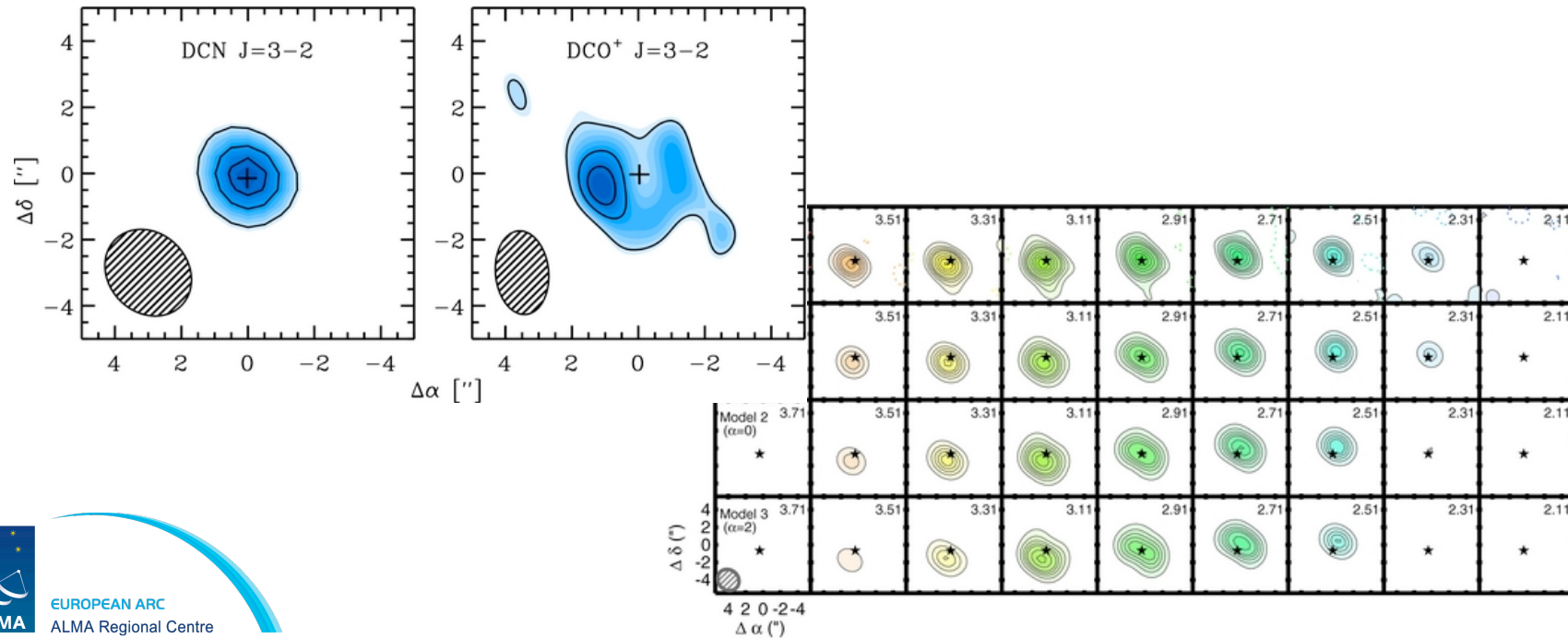


CO(3-2)

HCO+(4-3)

# TWHya Band 6

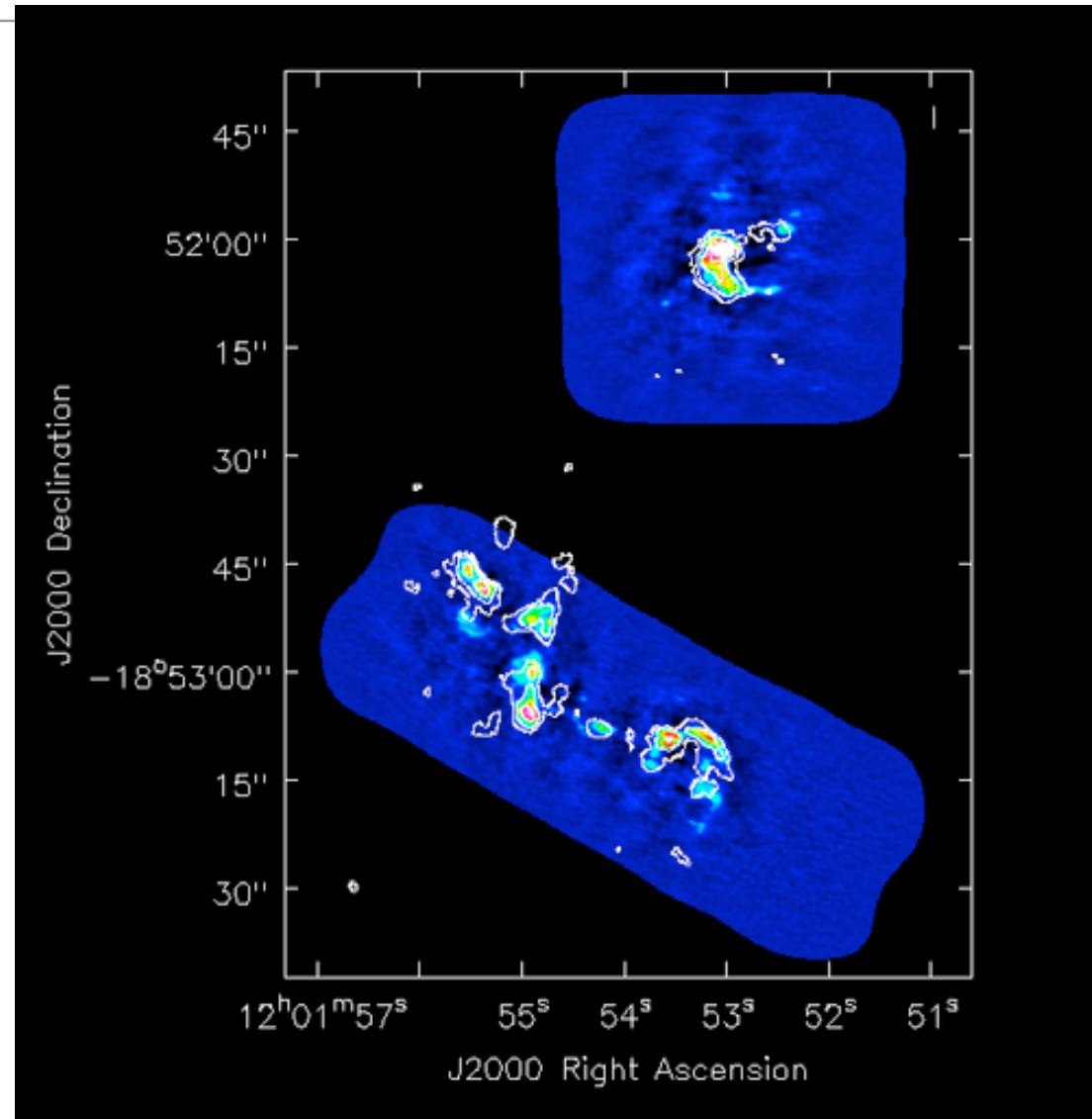
- Öberg et al 2012 - Deuterium fractionation in TWHya: Evidence for multiple pathways to Deuterium enhancements in protoplanetary disks
- Caution in interpreting range of deuterium fractions observed in solar system bodies



# ALMA Science Verification: Antennae galaxies

**Colors:** ALMA SV CO  
(3-2) data

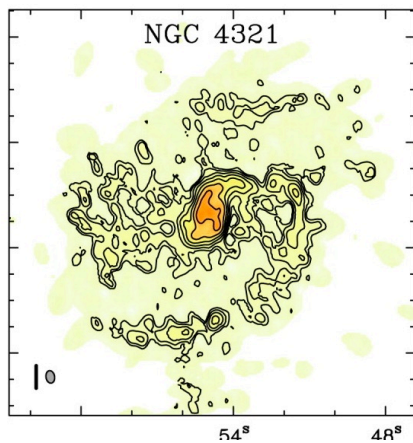
**Contours:** SMA CO  
(3-2) data (Ueda, Iono,  
Petitpas et al.)



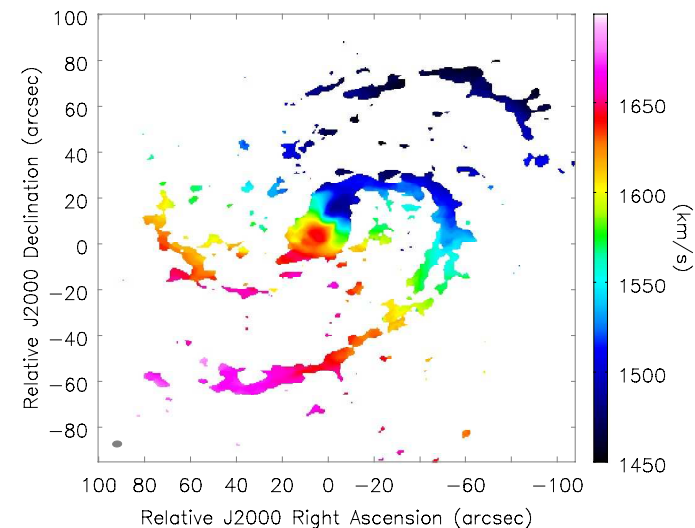
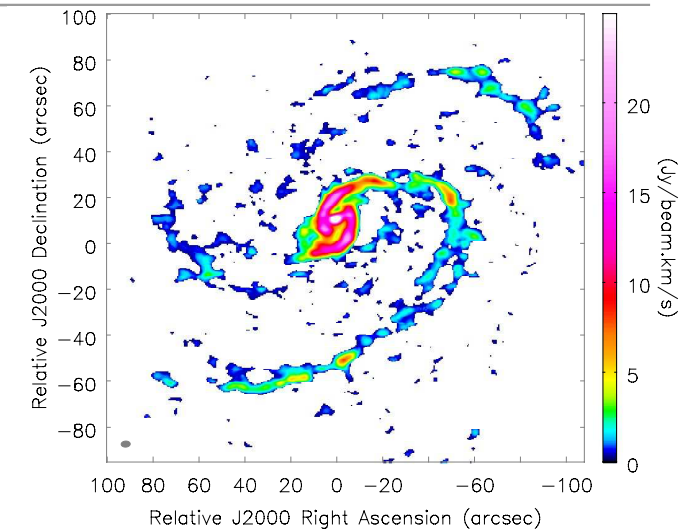


# ALMA Science verification: M100

- Grand design spiral in Virgo
- CO(1-0) line (band 3) observed with 13 antennas - 47 pointing mosaic
- A very good target to test combination of ACA and single dish data with main array

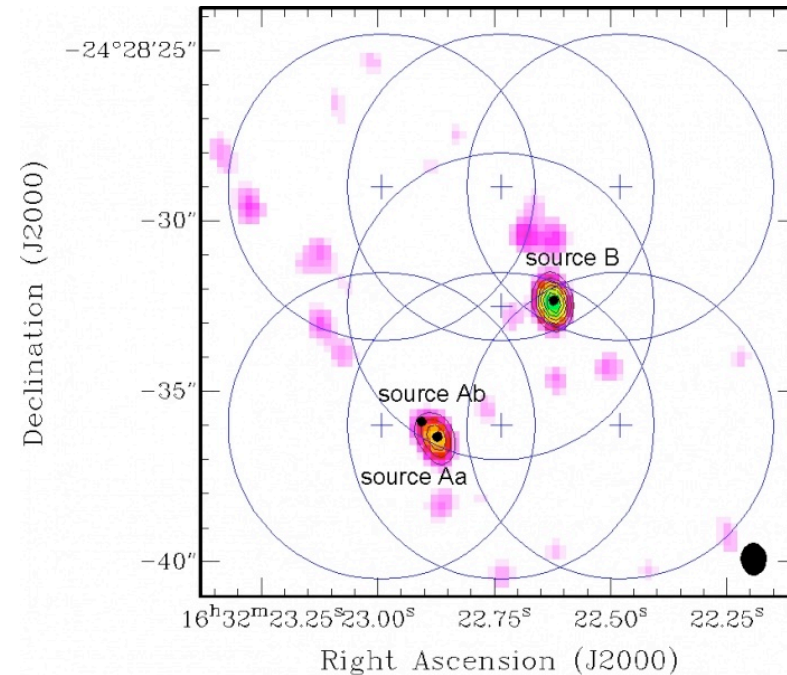


BIMA + 12m OTF map  
from Helfer et al 2002



# IRAS16293 band 6 and 9

- IRAS 16293-2422 (d=160) is a well studied nearby proto-binary system
- Detailed structure and kinematics in the circumbinary envelope for each component
- Strong emission from complex organic molecules and other species associated with hot cores in massive star-forming regions
- Observed in Band 6 and 9
- Casaguide available for band 9 data reduction

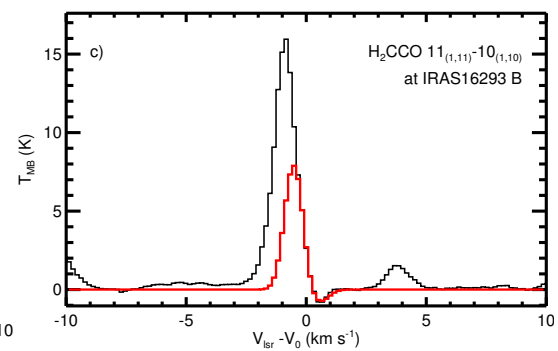
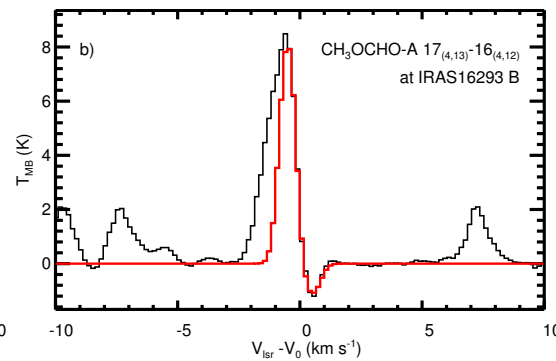
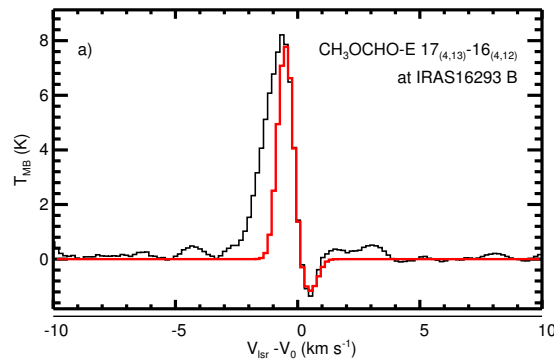
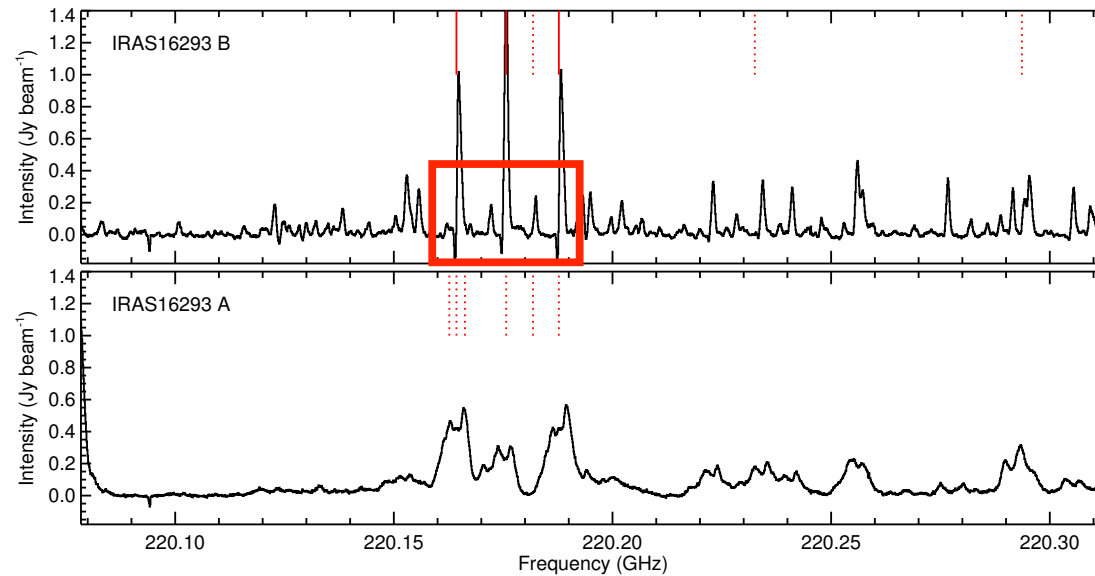
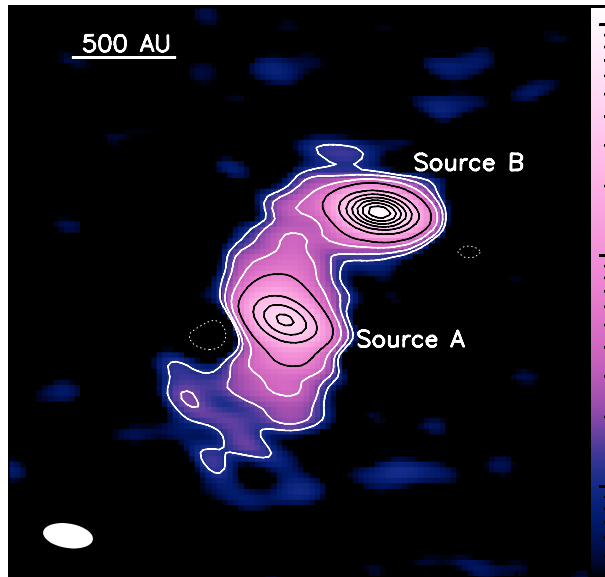


Band 9 mosaic

# A first ALMA look at IRAS 16293

Direct detection of infall onto source B & high-resolution kinematics of source A

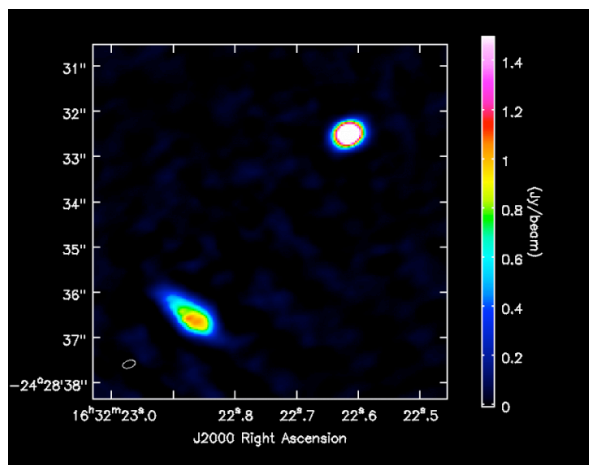
**Pineda, Maury, Fuller et al. (arXiv:1206.5215)**  
**also Jorgensen et al. (sub.)**



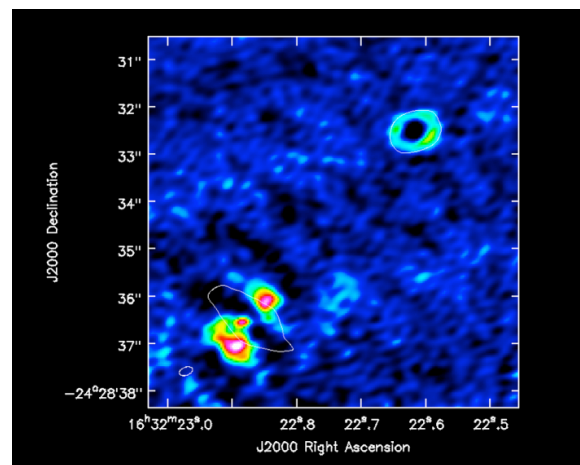
At 80 AU radius:

Supersonic infall velocity:  $0.50 \pm 0.05 \text{ km s}^{-1}$   
Infall rate :  $4\text{-}5 \times 10^{-5} M_{\odot} \text{ yr}^{-1}$

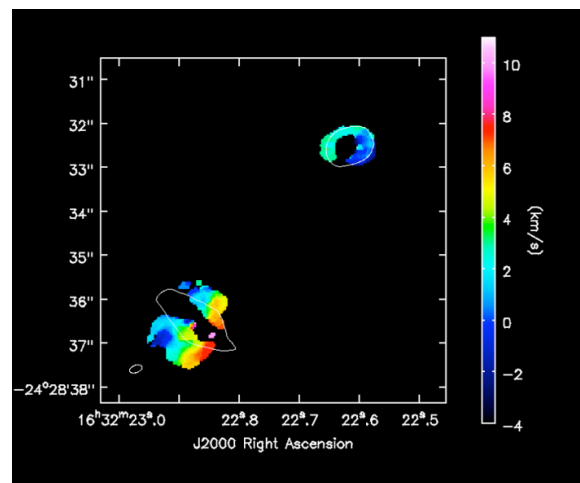
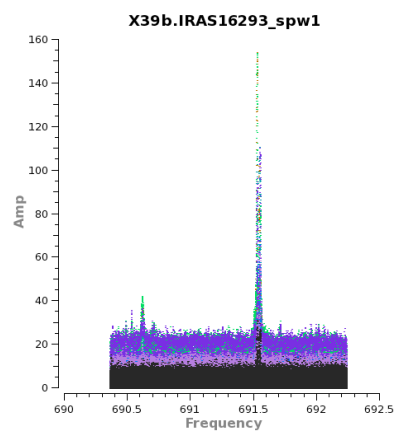
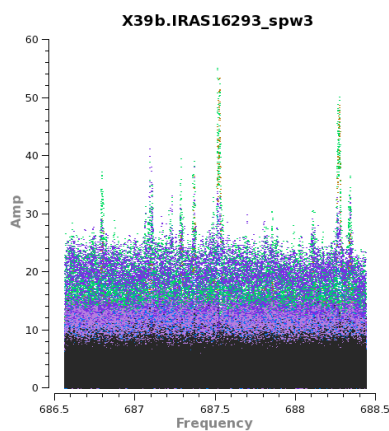
# IRAS16293 Band 9 - first Band 9 data!



700 GHz continuum

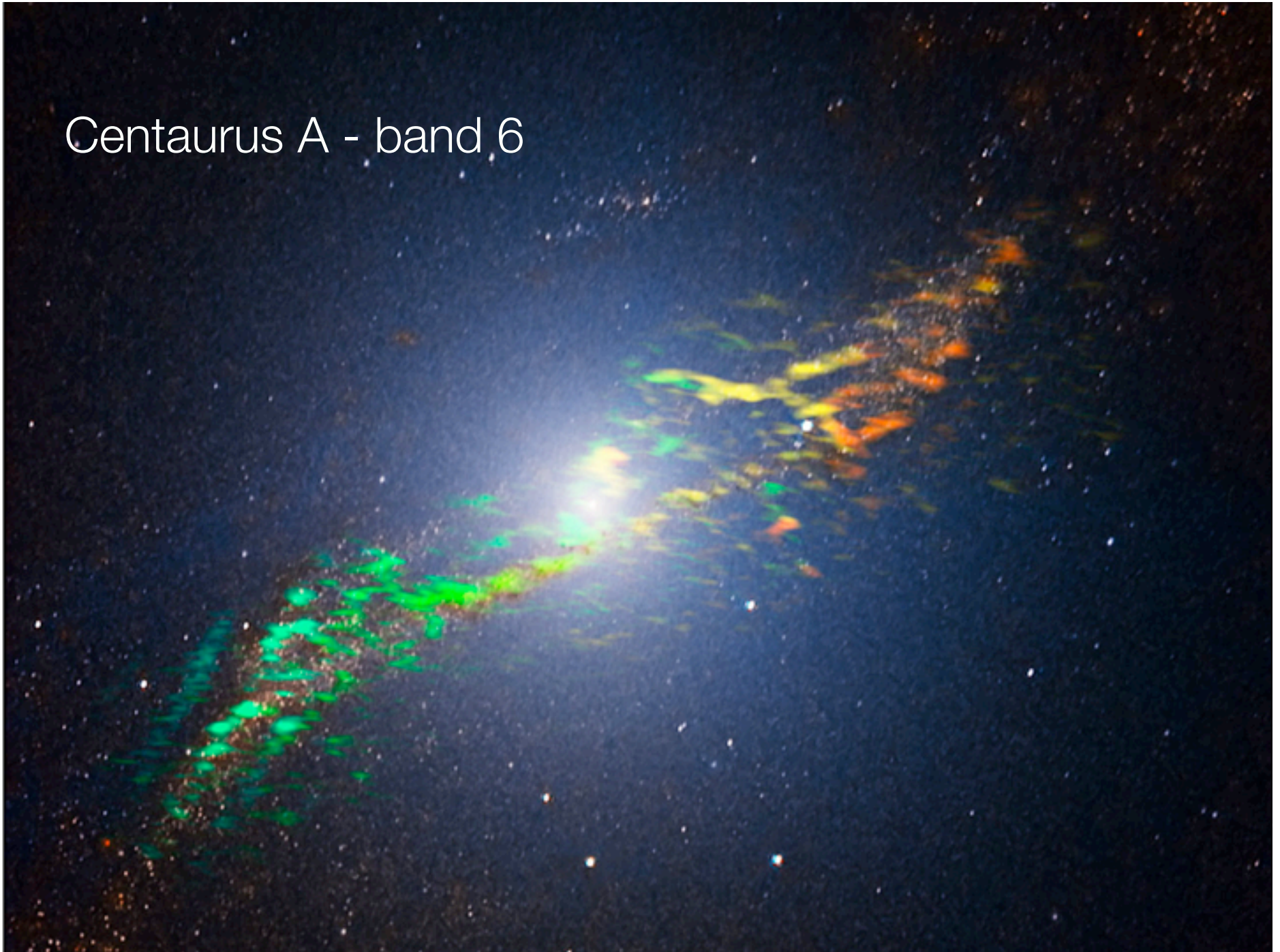


H13CN (J=8-7)  
moment 0



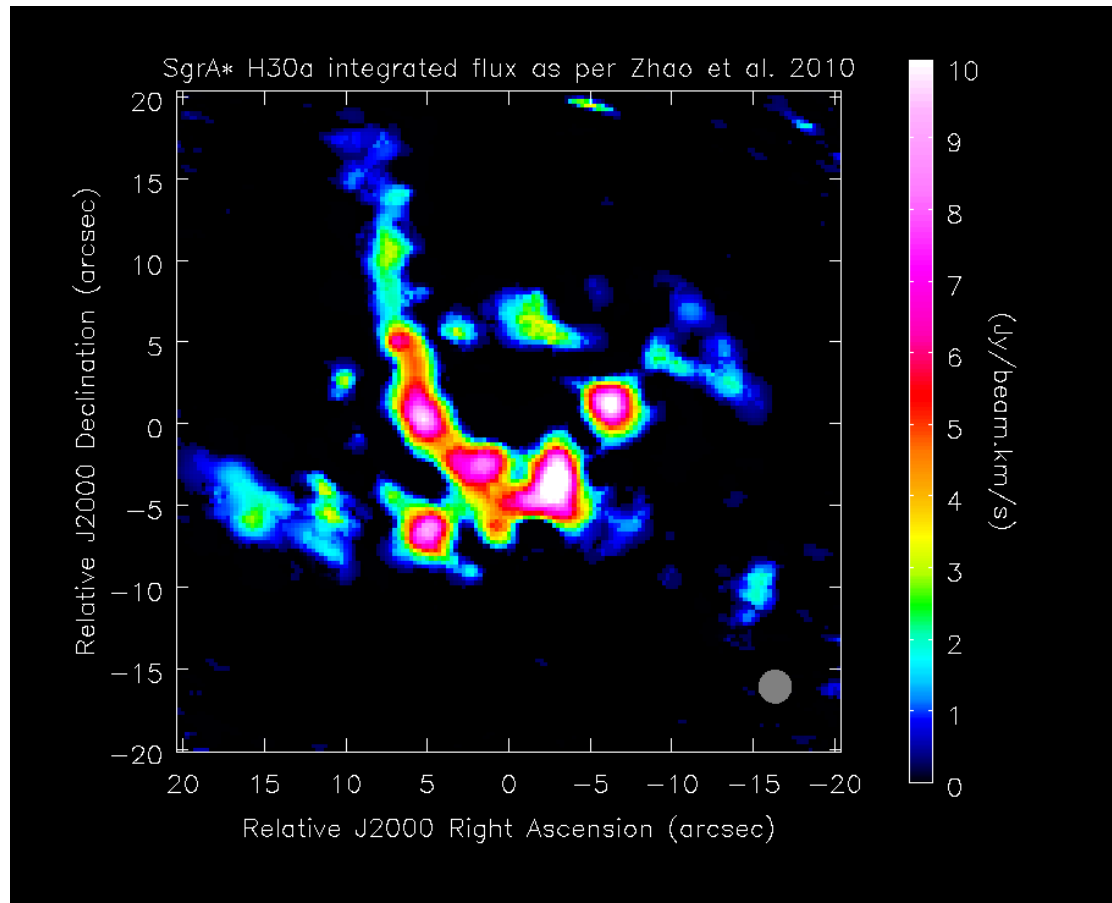
H13CN (J=8-7)  
moment 1

Centaurus A - band 6

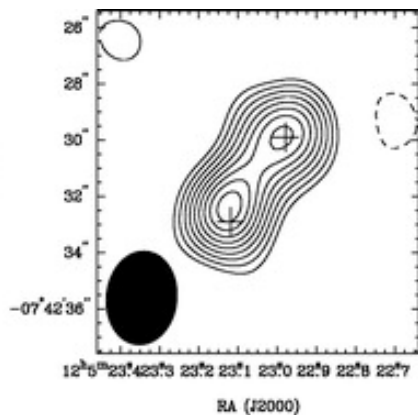


# Sgr A\* - Band 6

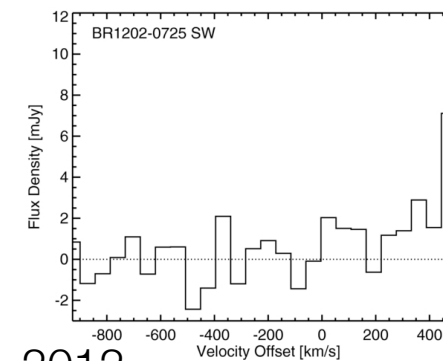
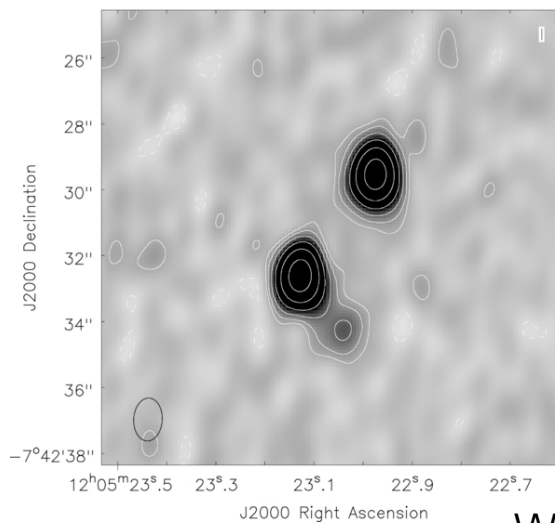
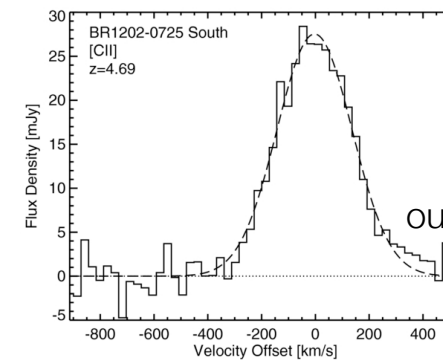
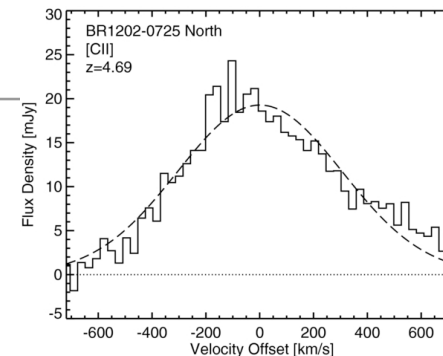
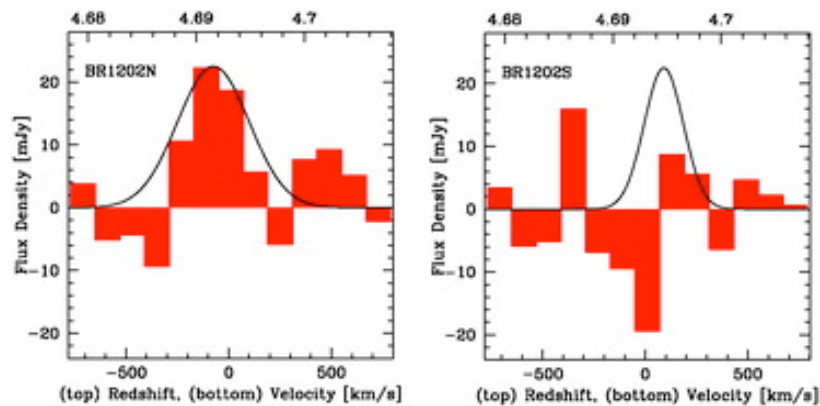
- Band 3 data will be released soon!



# galaxies at $z = 4.7$ : BR1202-0725



SMA: Iono 2006



Wagg et al. 2012

# Science Verification continues

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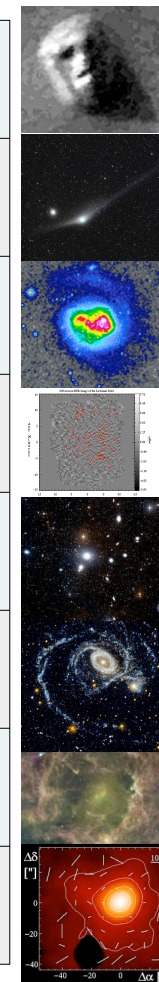
- Now: demonstrate the full range of Cycle 1 capabilities
  - Large mosaics
  - Mixed correlator modes
  - ACA and zero spacing
- Also, commissioning and science verification of:
  - Longer baselines
  - Polarization
  - Solar observing
  - On-the-fly mosaics





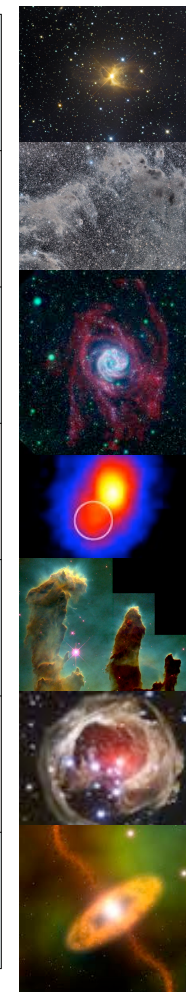
# New SV Targets

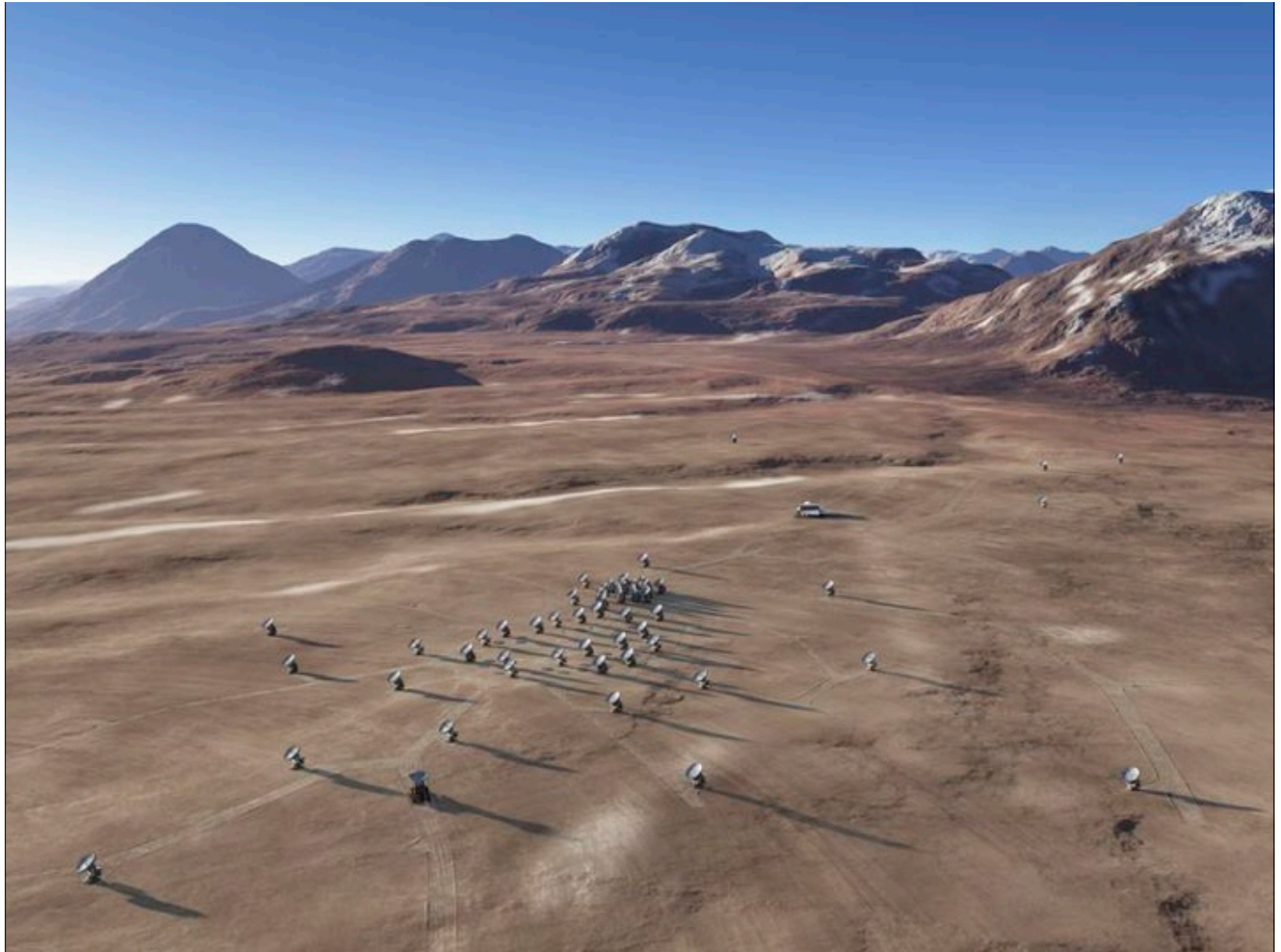
Mars	3,6,7 (CH <sub>4</sub> , CO)	12m+ACA +SD	mixed, 1 spw/ BB	multi-field calibration to exclude telluric lines
comet C/2009 P1 Garradd	3 (CO, HCN)	12m	mixed, 1 spw/ BB	external ephemeris files, transients
VV114	9 (CO)	12m+ACA	low spectral res	
SHADES	7 (contin)	12m	low spectral res	astrometry and multi-field interferometry
Fornax Cluster	3 (CO)	12m+ACA	low spectral res	multi-field and multi- velocity interferometry
NGC1512/10	3 (CO)	12m+ACA +SD	mixed, 1 spw/ BB	large mosaic
Lambda Orionis	3 (contin)	12m+ACA +SD	low spectral res	large mosaic, continuum SD
CB54	7 (CO(3-2), HCO+(4-3), ....	12m	mixed, multiple spw/BB	large mosaic



## New SV Targets (continued)

HR 3126/IC 2220	3 (CO, CN)	12m+ACA+SD	mixed, 1 spw/ BB	large mosaic
Chameleon	6 (CO, SiO)	12m	mixed, 1 spw/ BB	multi-field interferometry, long baselines
M83	7 (CO)	12m+ACA	mixed, 1 spw/ BB	On The Fly mosaic
RXCJ1347-1145	3 (contin)	12m+ACA	low spectral res	
M16	6 (CO)	12m+ACA+SD	mixed, 1 spw/ BB	large mosaic
G34.26+0.15	9 (H21a, CH3CN, 34SO2, SO2, CH3CN, HCO+	12m+ACA+SD	mixed, multiple spw/BB	
321, 325, 658 GHz water masers	7,9 (H2O)	12m	mixed, 1 spw/ BB	spectral averaging, high angular res, survey mode (non-multi-field)







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