ALMA Science: From Cycle 0 Results to Cycle 2 Preparation

Italian Node of the ALMA Regional Center

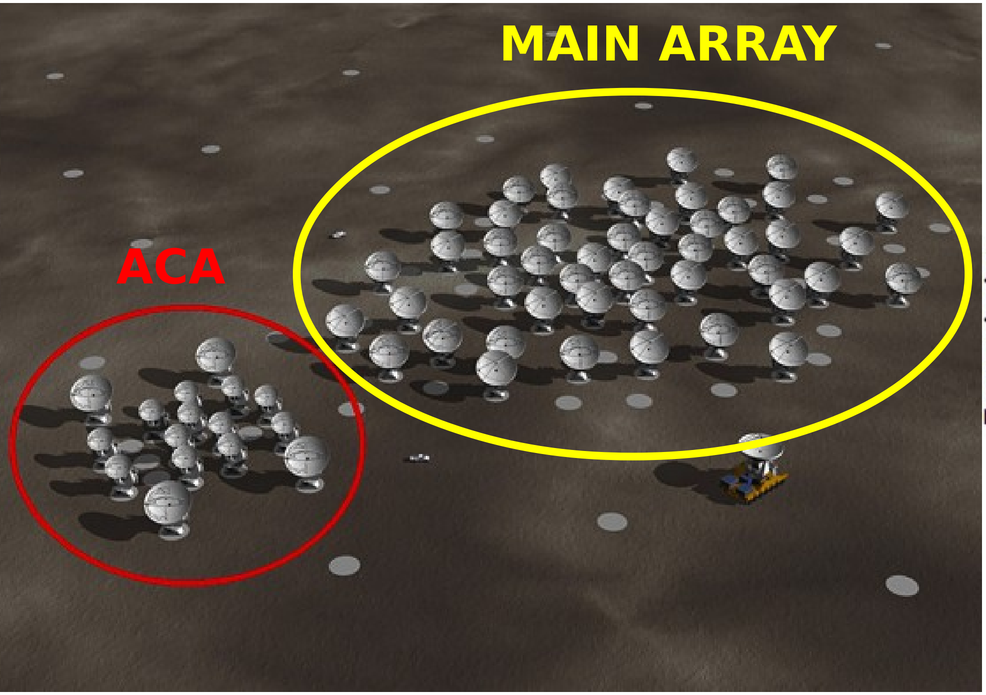
ALMA

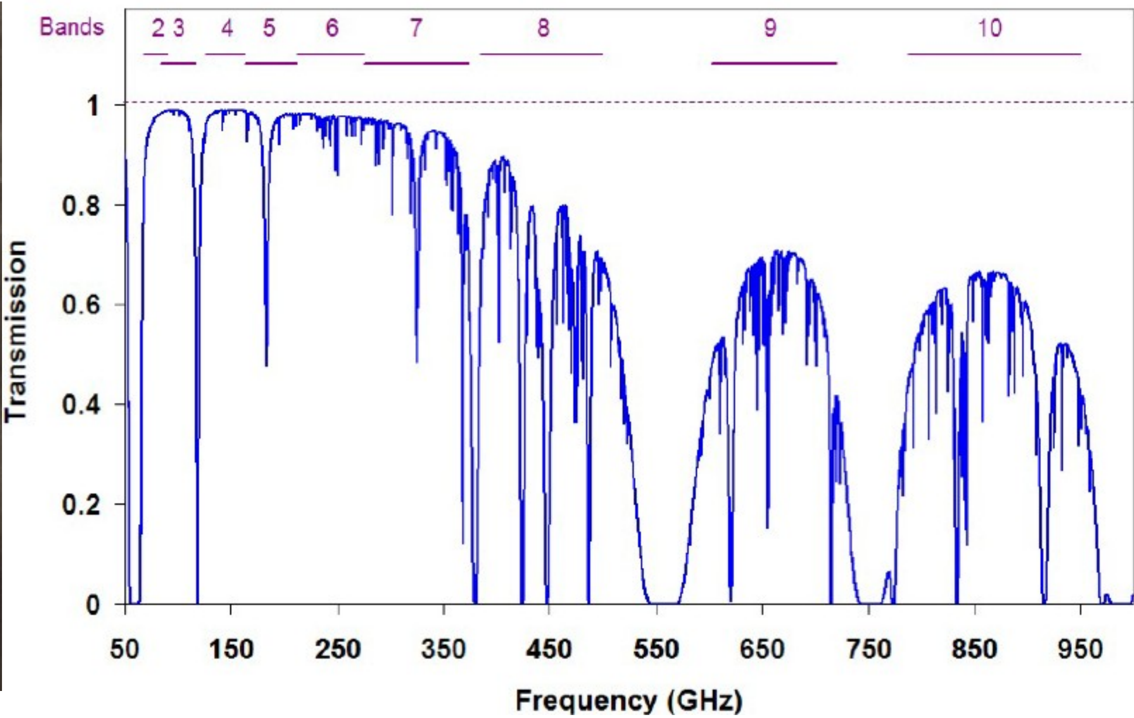
EUROPEAN ARC
ALMA Regional Centre || Italian

with the contribution of the Italian ARC staff:
Jan Brand, Viviana Casasola, Elisabetta Liuzzo,
Marcella Massardi, Arturo Mignano, Jeremie Boissier

ALMA: Atacama Large Millimeter/Submillimeter Array

- Inaugurated on March 2013 on the Chajinantor plain (**5000m**, Chile, latitude -23°): dry site, low precipitable water vapour, low Tsys, high sensitivity
- Antennas: **50x12m** main array + (**12x7m + 4x12m**) Atacama Compact Array (ACA)
- ACA for short-spacings and Total Power observations
- Frequency range: **10 bands between 30-950 GHz** (0.3-10 mm)
- Baselines length: **MAIN ARRAY: 15m → 150m-16km; ACA: 9m → 50m**





ALMA: Atacama Large Millimeter/Submillimeter Array

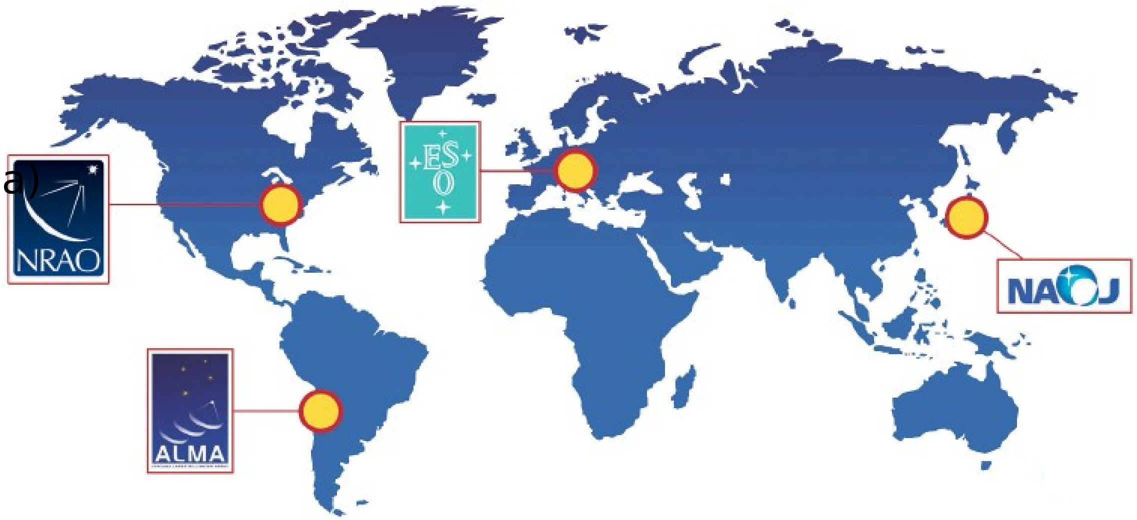
- Angular Resolution: **0.2'' x (300/freq_GHz)x(1km/max_baseline)**
  40 mas @ 100 GHz, 5 mas @ 950 GHz
- Velocity resolution: **As narrow as 0.008 × (Freq/300GHz) km/s**
  ~0.003 km/s @ 100 GHz, ~0.03 km/s @ 950 GHz
- FOV 12m array: **20.3''/(300/freq_GHz)**
- Bandwidth: **2 GHz x 4 basebands for each of 2 polarizations**
  sensitivity <0.05 mJy @100 GHz in 1 hr
- Polarimetry: Full Stokes polarization capability

The ALMA organization

World wide collaboration

- Europe: **ESO** (14 countries)
- North America: **NRAO** (USA, Canada)
- East Asia: **NAOJ** (Japan, Taiwan)
- Chile

Contributors share the observing time

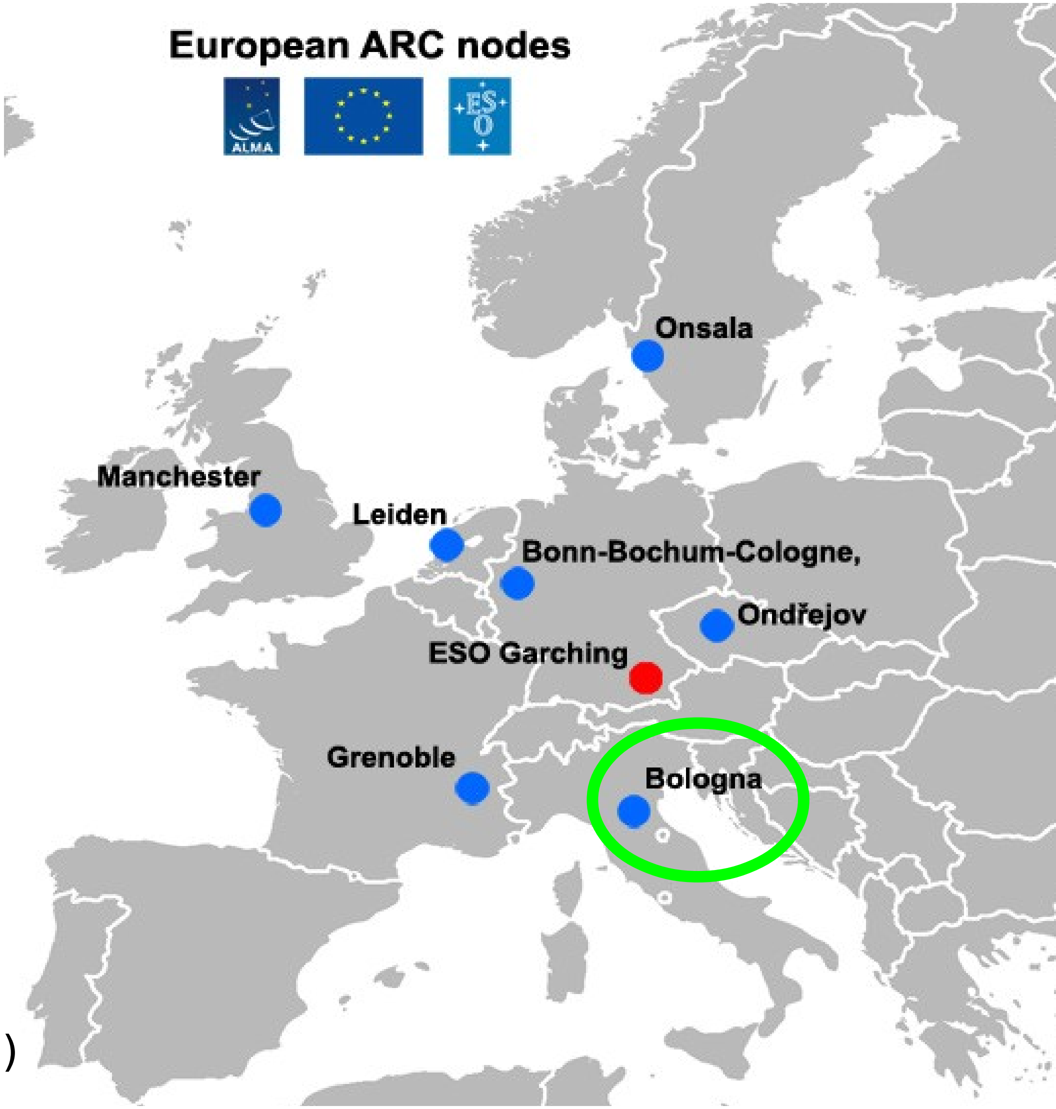


3 Sites in Chile

- **AOS**: ALMA Operations Site (5000m): Antennas, Correlator
- **OSF**: Operations Support Facility (3000m): Labs, Antenna Assembly & Maintenance Operators, Astronomers
- **SCO**: Santiago Central Office:
  - JAO (Joint ALMA observatory)
    - Call for Proposals
    - Running ALMA
    - Data Reduction Pipeline
    - Quality Assessment
  - Archive

The ALMA Regional Centers (ARCs)

- **Interface between JAO and users**
- 1 ARC per Partner:
  - NRAO for North America
  - NAOJ for East Asia
  - **ESO for Europe (split in 7 nodes)**
- Operation support
  - Archive replication
  - Astronomer on duty
  - Software tools
- User support
  - Community formation and outreach (schools, workshops, tutorials, ...)
  - Phase 1 (proposal preparation)
  - Phase 2 (scheduling block preparation)
  - Data analysis, Archive mining
  - F2F user support, Helpdesk



ALMA Current status:

All the antennas have completed Assembly, Integration and Verification at the OSF at 3,000m and almost all have been transported to the AOS at 5,000m

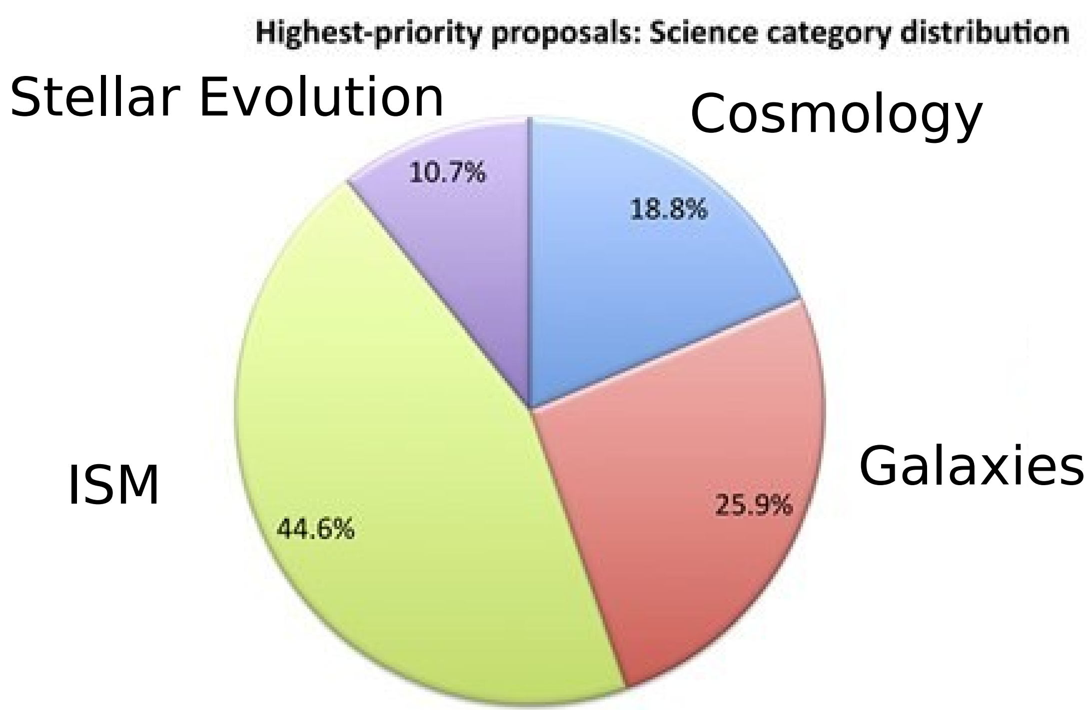
ALMA Early Science:

allows community to observe with incomplete, but already superior array, on best effort basis:

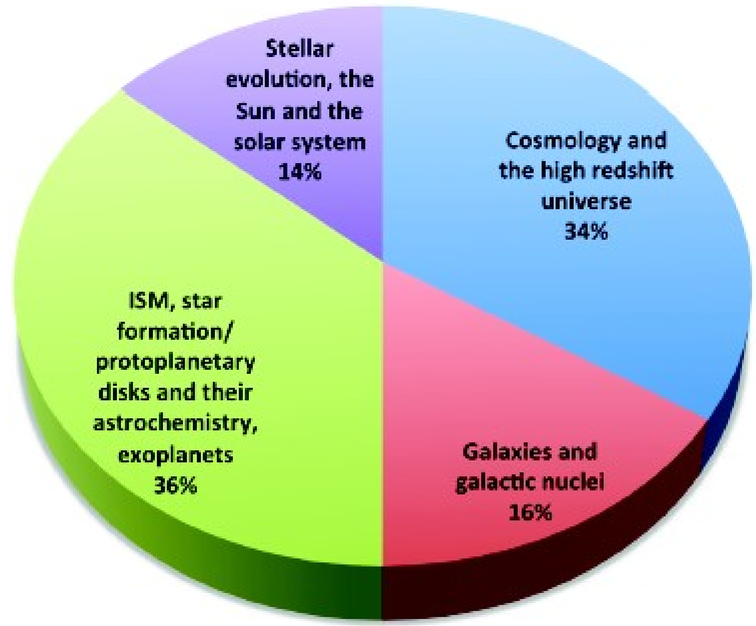
- Cycle 0: Sep. 2011 – Jan. 2013
- Cycle 1: Jan. 2013 – May. 2014
- **Cycle 2 call for proposals: 24 October 2013, Deadline: 5 December 2013**

Cycle 0:

- 111 Highest-priority + 51 filler proposals (out of 919 submissions)
- 108 (98%) Highest-priority PIs received some data



Cycle 0 Publications by Category



As of Nov 19 2013

75 referred publications

32 based on SV data

43 used Cycle 0 data

~10% Nature/Science

Major impact so far in Cosmology/high z

and ISM/StarPlanForm/Astrochemistry

Most of the following results were presented at

“The first year of ALMA Science” conference

Puerto Varas, Chile, December 12-15, 2012

See http://www.almasc.org/ for references

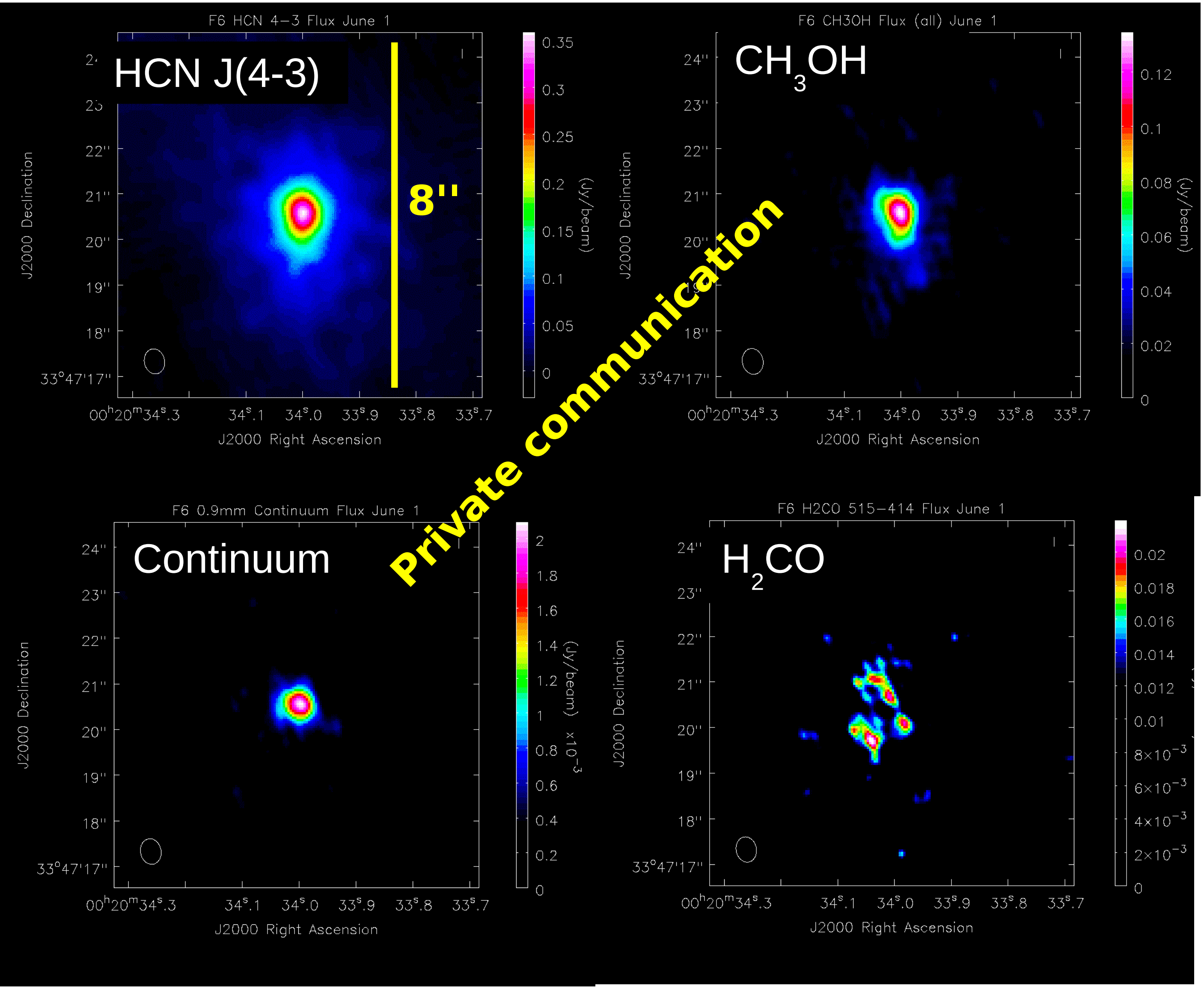
	Full array	Cycle 0
Frequency range:	**10 bands 30-900 GHz**	**4 bands (3, 6, 7, 9)**
Antennas:	**50x12m +** ACA	**16x12m** (no ACA)
Sensitivity	**0.15 mJy in 1 min @ 230 GHz**	**0.5 mJy in 1 min @ 230 GHz**
Max baseline:	**150m-16km**	**2 configs: 18-125m, 36-400m**
Angular Resolution:	**20 mas @ 230 GHz**	**1000 mas @ 230 GHz**
	70 correlator modes	**14 correlator modes**
	Mosaic capability	**Limited mosaic** capabilities
	Pipeline reduction in Chile	**Reduction @ ARCs**

Solar System and Protoplanetary Disks

- Planetary and cometary atmospheres (Comet C/2012 F6 Lemmon)
- Study of climate models on solar system planets
- Proto-planetary disk structure (HD 142527, Fomalhaut)
- Disk properties through stellar evolution epochs (G35.20-0.74N)
- ……

PI: M. Cordiner

Comet C/2012 F6 Lemmon with ALMA



OBSERVATIONS

- Cycle 1 Director's Discretionary Time proposal
- 1.2 hr on-source
- Band 7 (0.8-0.9 mm): HCN, CH_3OH, H_2CO
- 30 antennas in compact configuration
- May 31 – June 2 2013

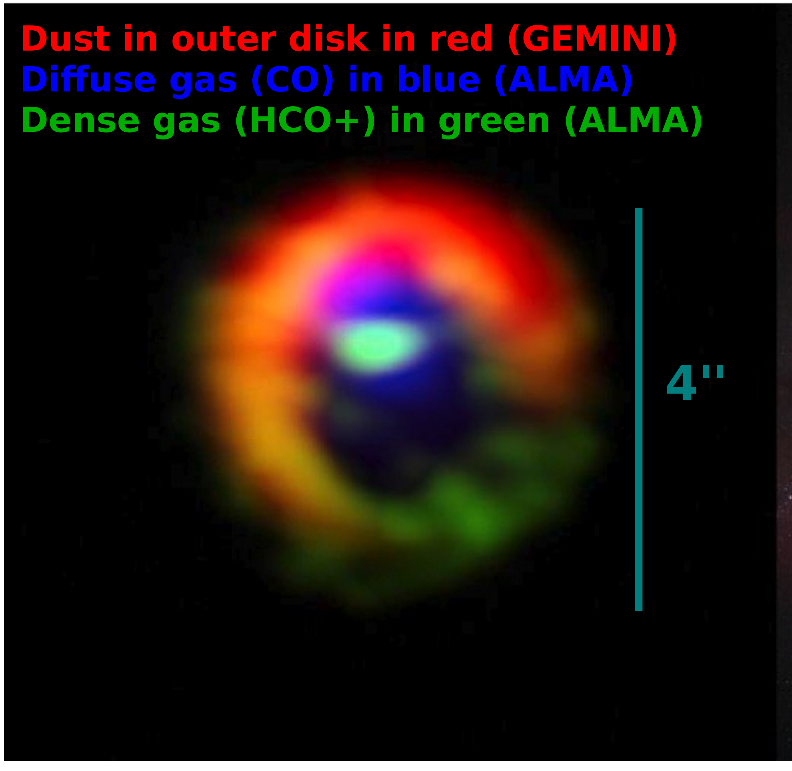
PRELIMINARY RESULTS

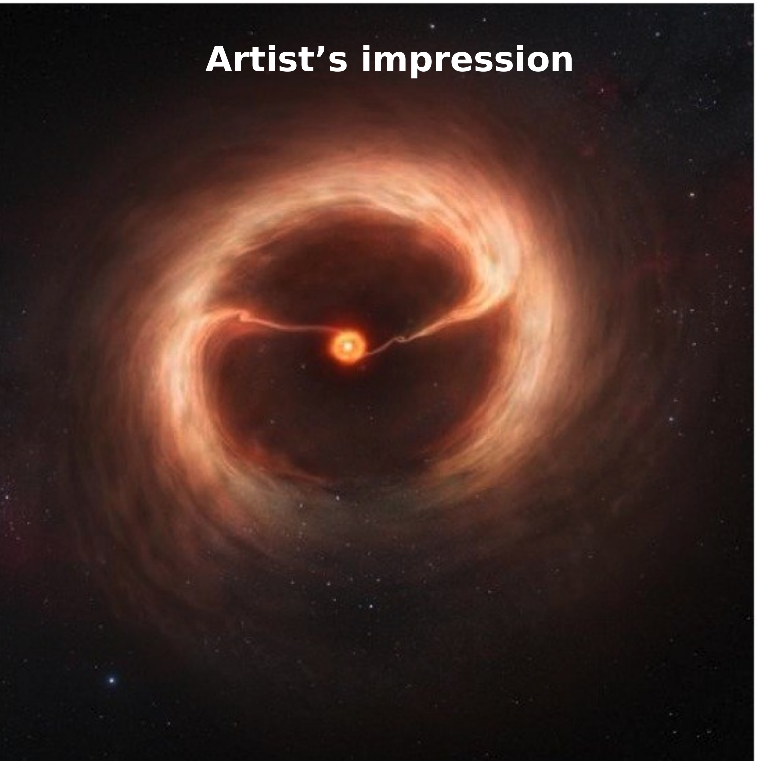
- **First ALMA observations of a comet**
- H_2CO: not peaked, clumps
- Chemical origin of these molecules
- **Coma release mechanisms**
- **Organic molecules: impact on Astrobiology**

Cordiner et al. 2013: Proceeding

PI: S. Casassus

Flow of gas through a protoplanetary gap: HD 142527





OBSERVATIONS

- Herbig Ae star, D = 140 pc from the Earth
- 2 Myr, 1.9 $M_\odot$, **young massive star**
- Inner disk 10 AU, outer disk 140 AU, planetary body 90 AU
- Band 7: CO(3-2), HCO^+(4-3), continuum
- **Angular resolution ~0.6''**

Casassus et al 2013

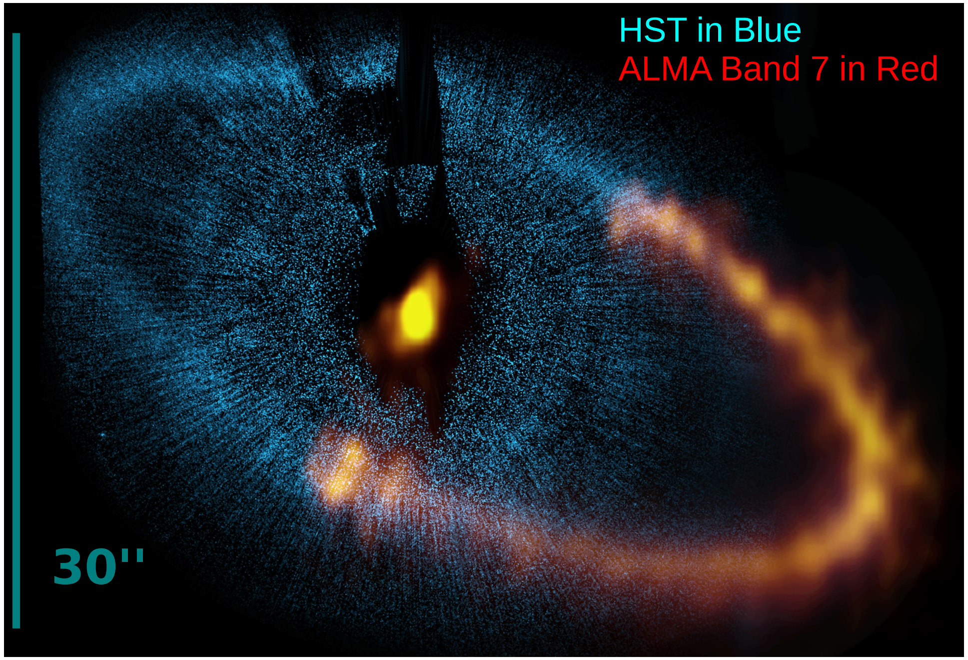
RESULTS

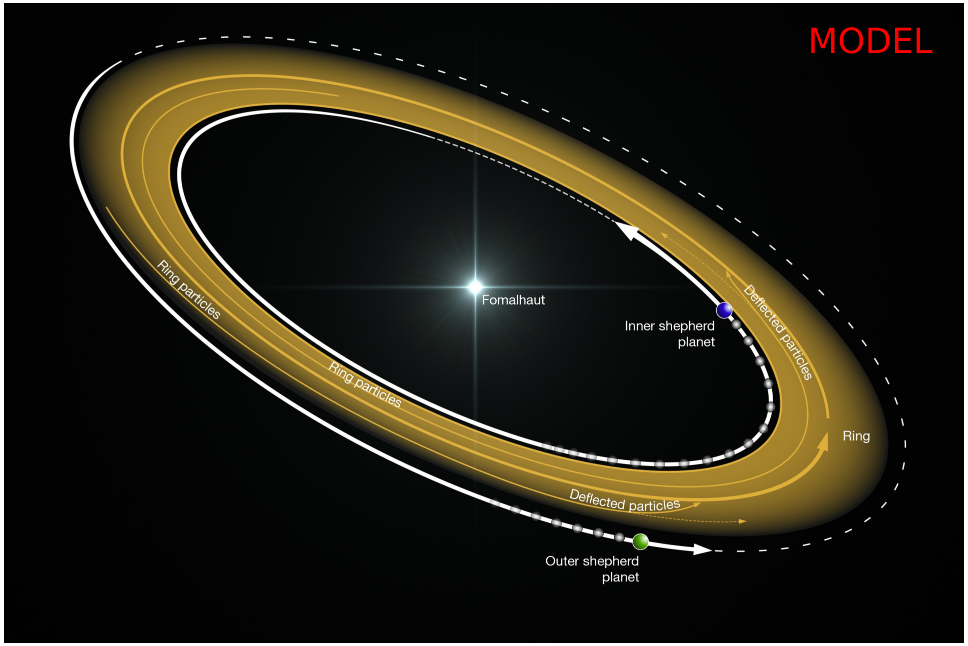
- **First detection of diffuse CO inside the dust gap**
- **HCO^+ in dense outer disk and cross-gap filaments with res. comparable with optical**
- Filaments and residual gas in gap suggest gas inflow towards the star
- HCO^+ mass flow rate ~10^{-8} $M_\odot$/yr, sufficient to maintain accretion at the present rate

Constraint the planetary system: Fomalhaut

PI: S. Boley

The dynamical evolution of planetary systems leaves observable signatures in debris disks





OBSERVATIONS

- A3V star with a debris ring
- D = 7.69 pc from the Earth
- Band 7 – continuum
- Half of the disk
- 140 min on source
- rms~0.06 mJy/beam
- **Angular resolution ~1.5''**

RESULTS

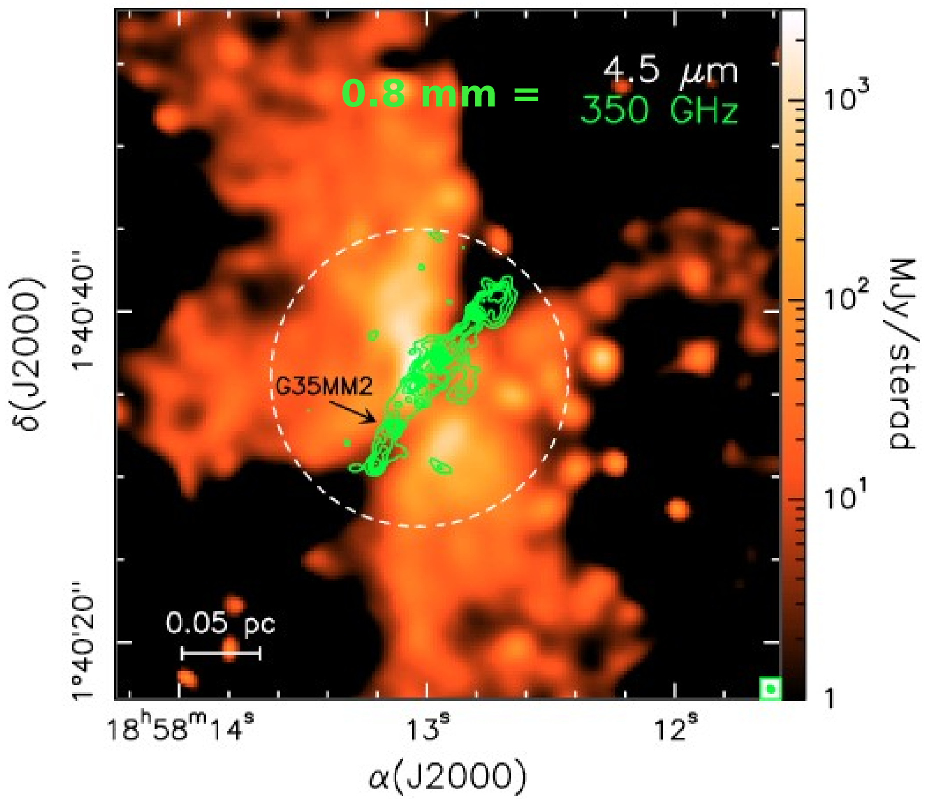
- ALMA traces **large grains (1mm), not moved by star radiation**: disk's sharp edges and ring-like structure
- Models: **2 planets** in the sharp inner (13 AU) and outer (19 AU) boundary

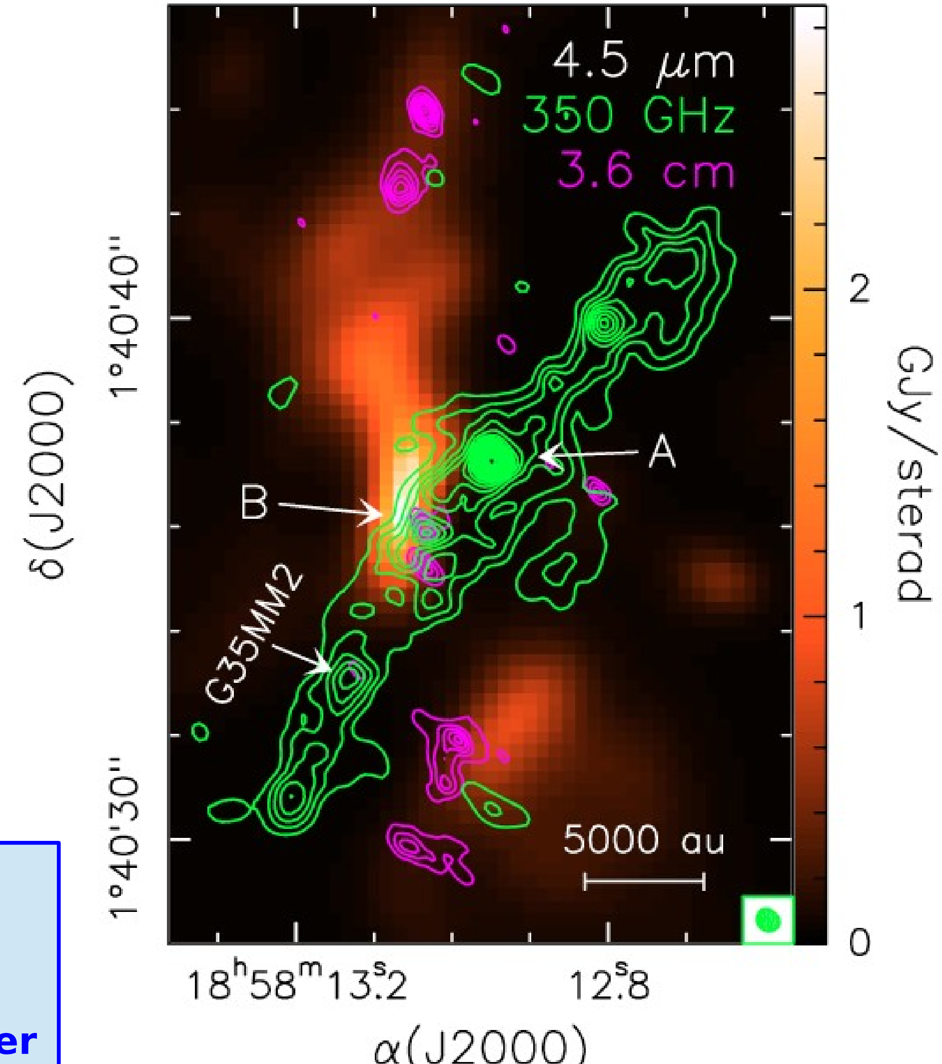
Boley et al 2012

PI: R. Cesaroni

A candidate circumbinary Keplerian disk in G35.20-0.74 N

A detailed investigation of the disk properties around high-mass star (OB-type) was missing to limited previous angular resolution at mm



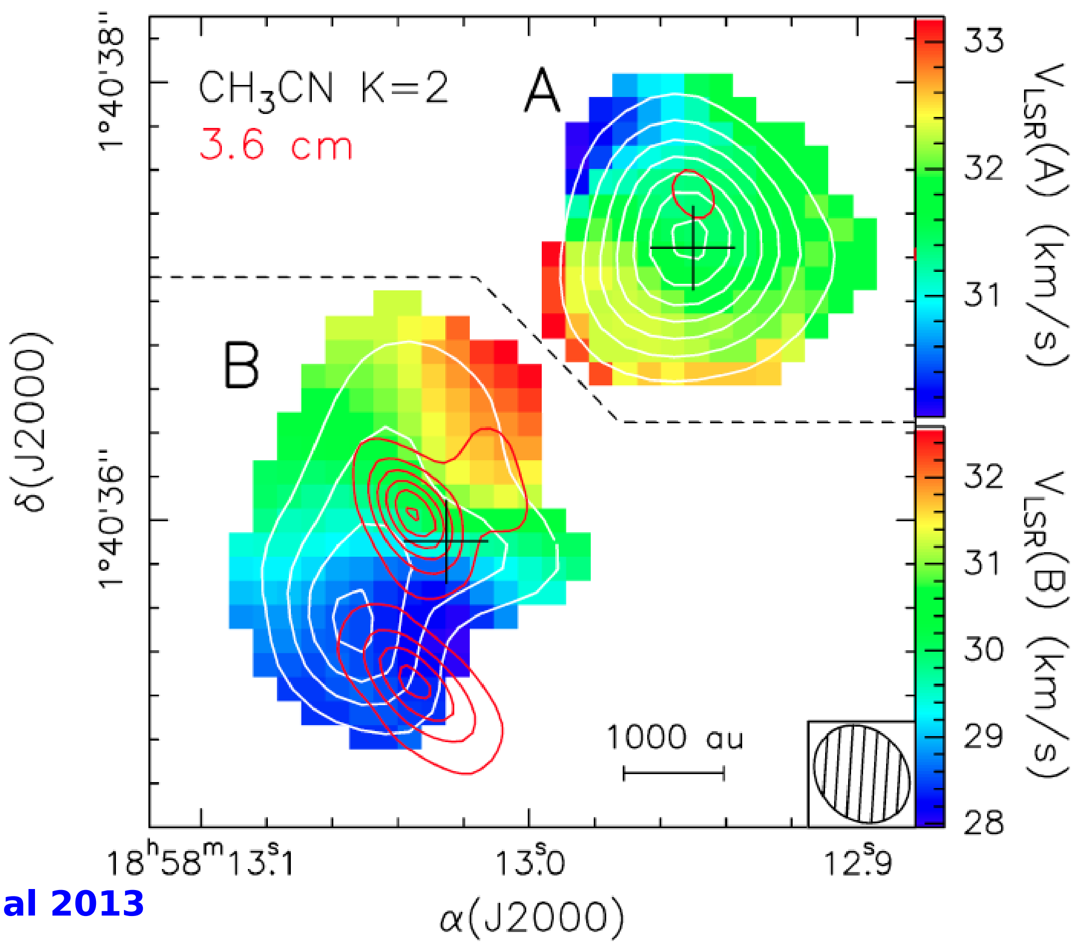


- Star forming region at 2.19 kpc
- Band 7 (350 GHz): continuum + CH_3CN
- **Angular resolution ~0.5'', 7 times better than previous mm observations**
- YSOs are powering outflows in A and B cores

Sanchez-Monge et al 2013

PI: R. Cesaroni

A candidate circumbinary Keplerian disk in G35.20-0.74 N



Sanchez-Monge et al 2013

- The 2 dense cores are detected also in CH_3CN (hot-core tracer) with velocity gradient
- **Core B: edge-on Keplerian disk** rotating about a central mass of ~18 $M_\odot$
- Core B: Disk radius ≥2500 AU, disk mass ~3 $M_\odot$
- **Core B: Evidence of binary system of stars** comparing bolometric luminosity and estimated stellar mass

ISM and Star Formation

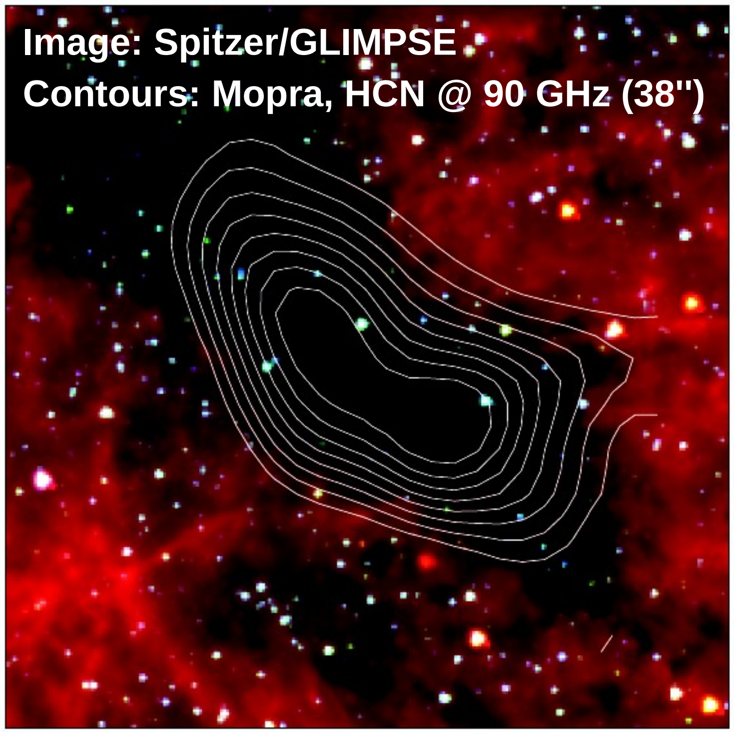
- Structure of molecular outflows in new-born stars (HH 46/47)
- High-mass star formation in IR dark clouds (G0.25+0.16)
- Mechanisms of massive star formation (SDC335)
- Astrochemistry and low-mass star formation (IRAS 16293-2422)
- ……

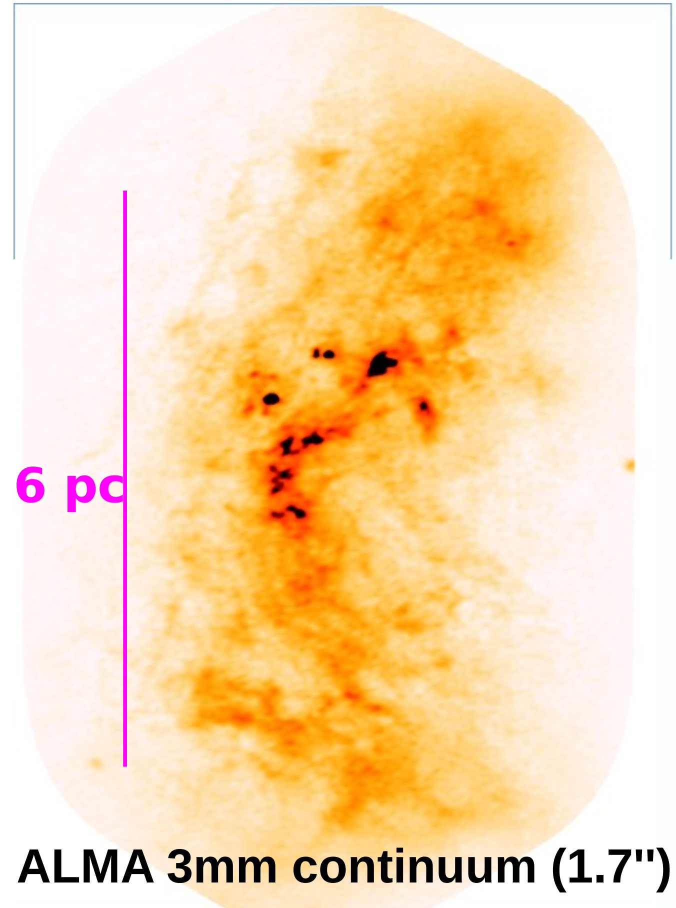
PI: J. Rathborne

Massive proto-cluster formation: caught in the act

G0.25+0.16 is a cold, dense, massive clump that is maybe the progenitor of young massive clusters (YMCs).

Continuum and molecular line surveys to identify precursor of YMCs: No evidence for ongoing star formation.





ALMA 3mm continuum (1.7")

OBSERVATIONS

- **G0.25+0.16:** 90 GHz (Band 3) **continuum and HCO^+, HNCO, SiO**
- 13 point mosaic
- 25 antennas, synthesized beam **1.7'' = 0.07pc**
- Continuum rms 0.20 mJy/beam
- Line rms 0.70 mJy/beam per channel

PRELIMINARY RESULTS

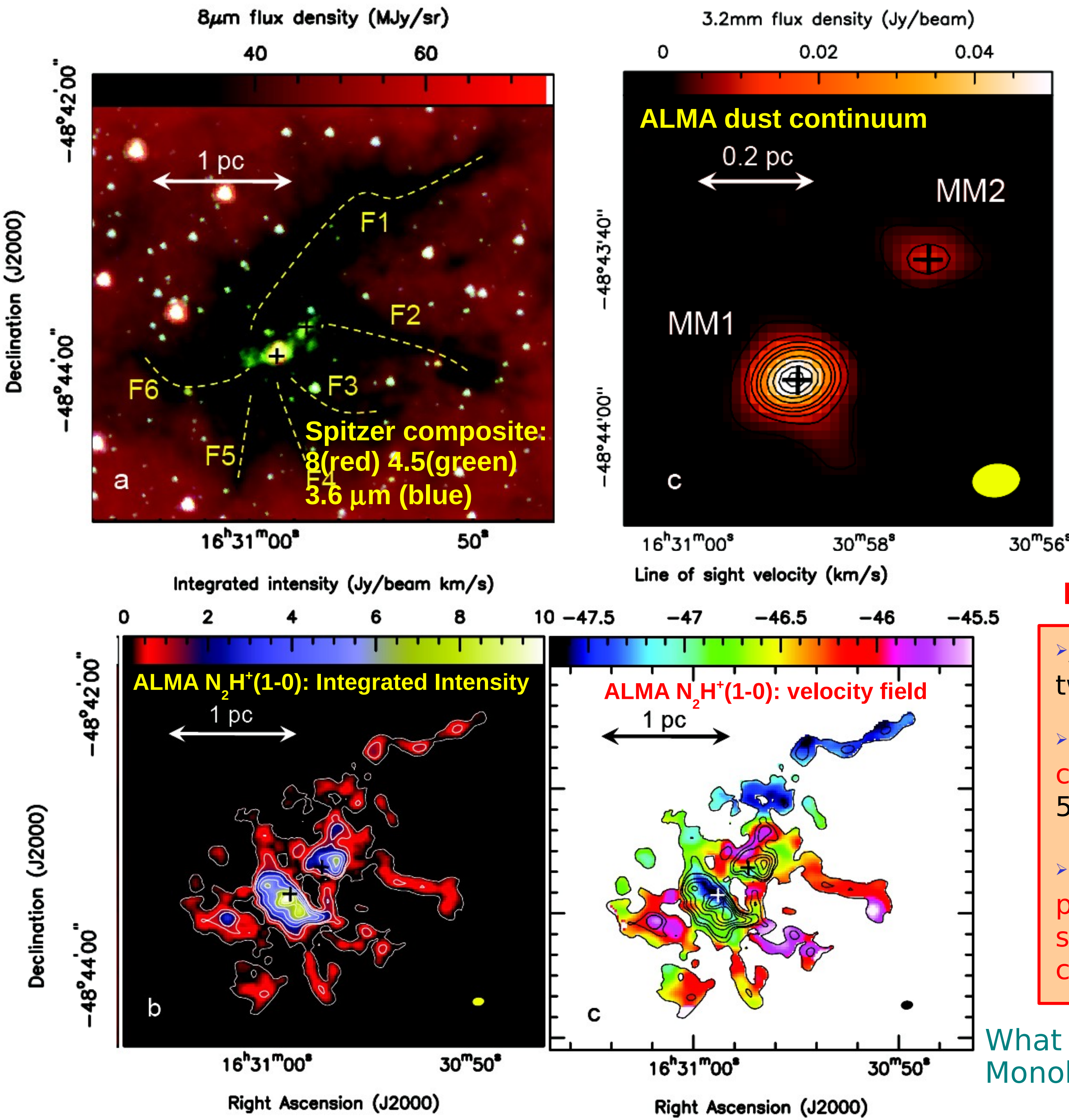
Location, mass, and kinematics of its **small-scale fragments**

Filaments with a very complicated **velocity structure and chemical pattern**

Large-scale shock fronts, small scale outflows

Where do massive stars get their mass from?

PI: N. Peretto



OBSERVATIONS

- **SDC335: massive IR dark cloud**
- 3.25 kpc from the Sun
- 3mm (Band 3) dust continuum and CH_3OH(13-12) and N_2H^+(1-0)
- 16 antennas, 11 mosaic points
- Beam = 5.6'' x 4.0''
- Vel. Resolution = 0.1 km/s
- Continuum rms 0.40 mJy/beam
- Line rms 14 mJy/beam

RESULTS

- ALMA dust continuum: resolved the two IR protostars
- MM1: the most massive protostellar cores ever observed in the Galaxy, 545 $M_\odot$
- First obs of network of cold, dense, pc-long filaments: velocity field suggests that SDC335 is globally collapsing along converging filaments

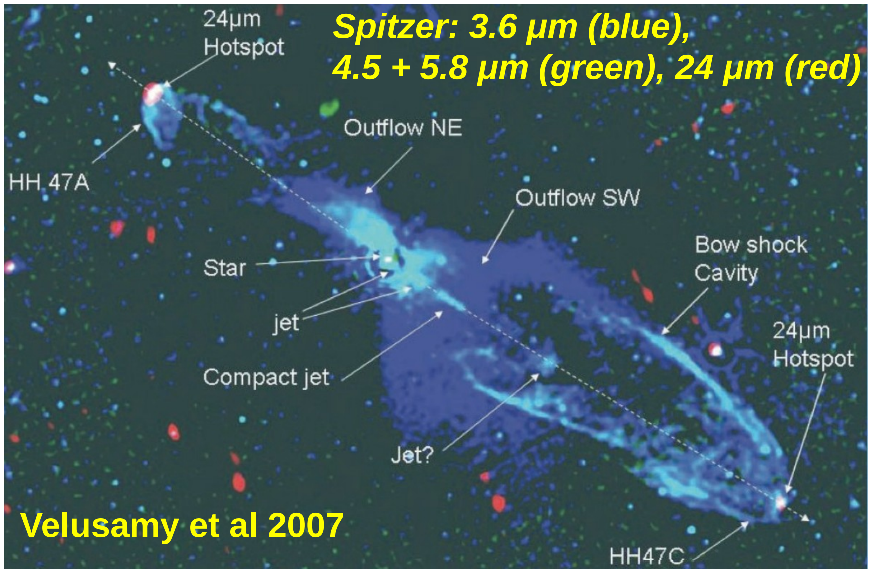
What is the general mechanism?
Monolithic collapse vs competitive accretion

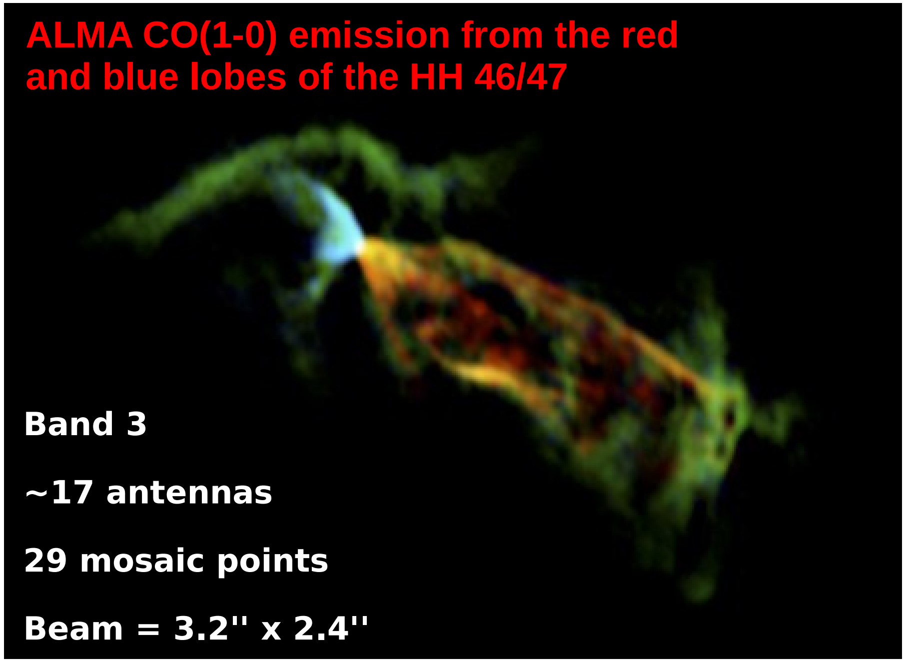
Peretto et al 2013

PI: D. Mardones

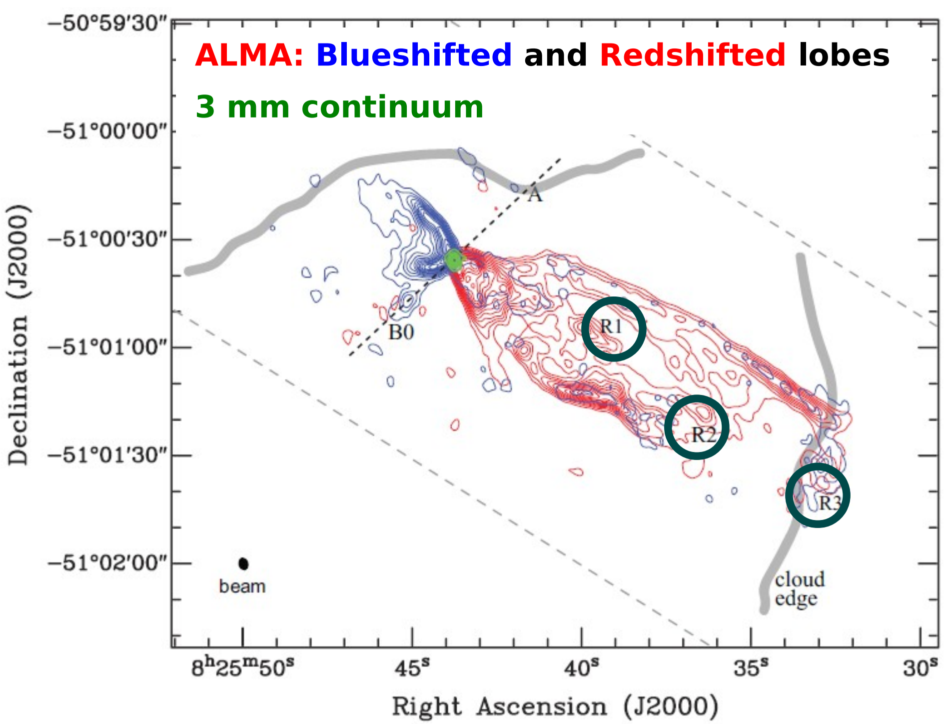
ALMA observations of the HH 46/47 molecular outflow

Observation of outflow almost invisible in optical: obscuration by the dust clouds surrounding a new-born star





- **First interferometric map of the CO outflow associated with HH 46/47**
- Red lobe: 3 clumps indicate multiple ejection episodes
- Outflow emission at much higher velocities than expected from previous observations (-30 km/s blue, 40 km/s red)
- If HH 46/47 is representative: **similar molecular outflows may be much more energetic than previously thought**



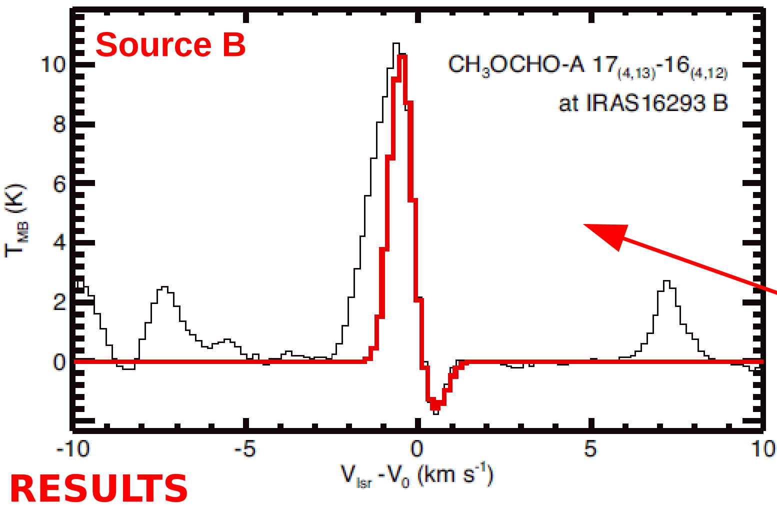
Arce et al. 2013

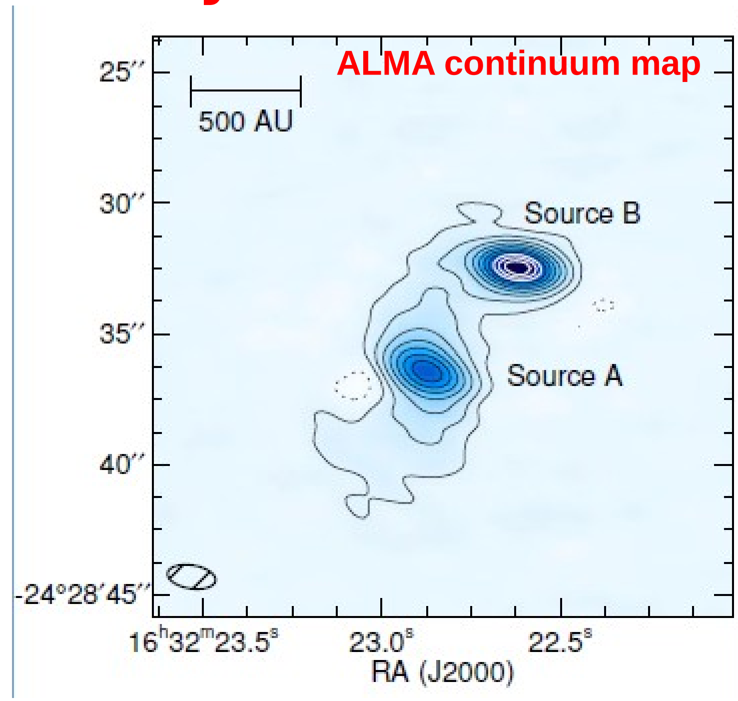
Pineda et al 2012

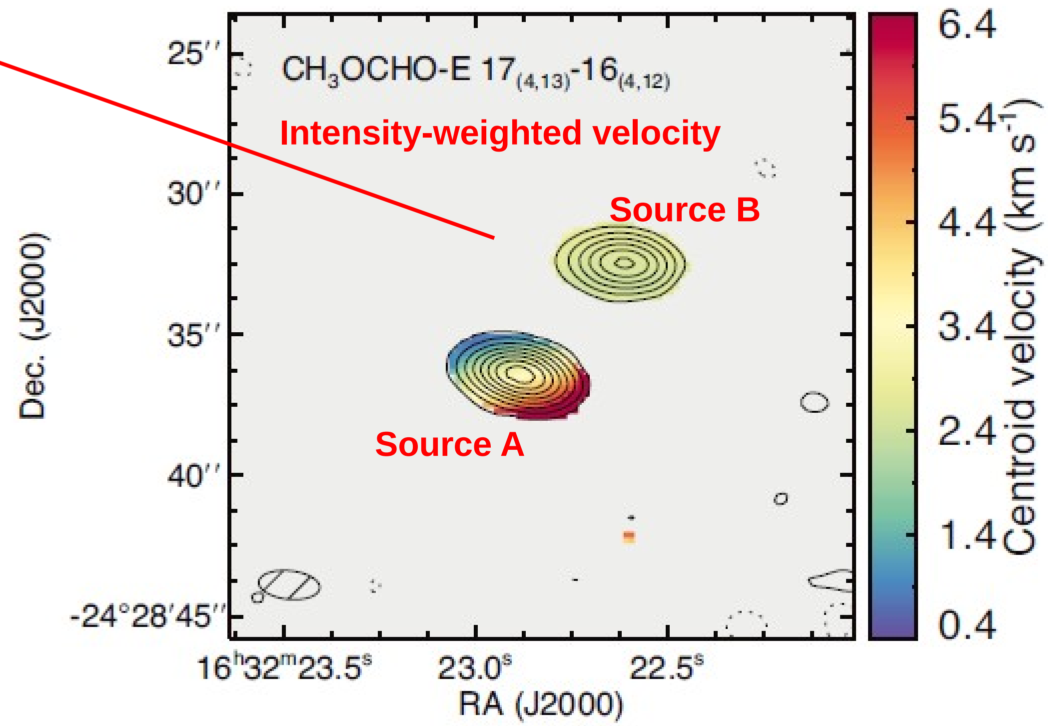
The First ALMA view of the proto-binary IRAS 16293-2422

OBSERVATIONS: Science Verification

- Band 6: ~220 GHz
- ~16 antennas; angular resolution 2.5'' x 1.0''
- Spectral resolution ~0.08 km/s
- 5.4 hrs on source



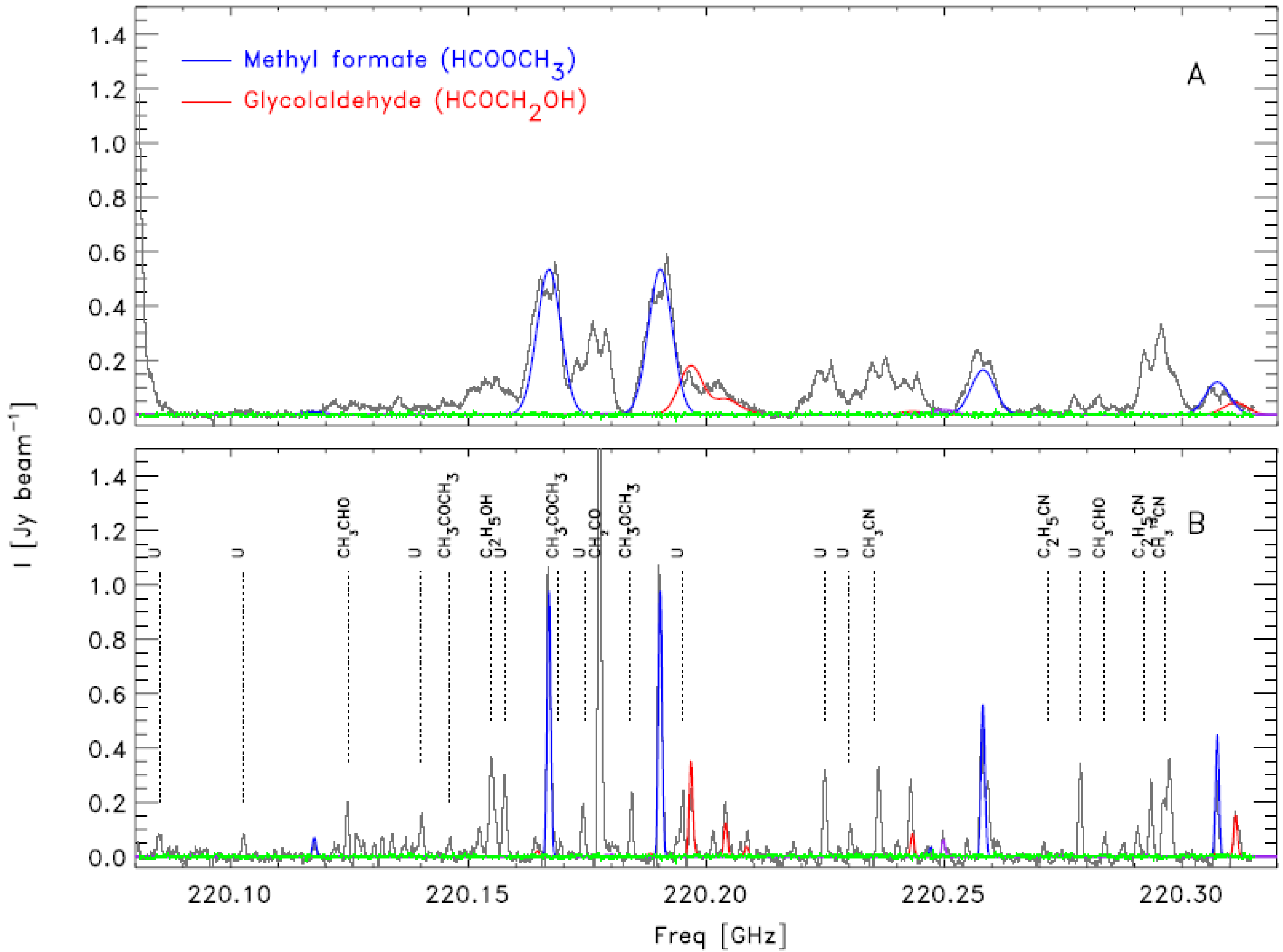




RESULTS

- **Source B**: First detection of an inverse P-Cygni profile in 3 emission lines → Infall → at the beginning of pre-main sequence
- Infall rate of 4.5×10^{-5} $M_{\odot}$/yr
- **Source A**: strong velocity variation consistent with rotation of a disk ~ edge-on

Detection of glycolaldehyde in IRAS 16293-2422



Jørgensen et al 2012

- Rich spectrum: ~30% of lines remains unassigned
- **6 lines of glycolaldehyde: $HCOCH_2OH$** -- > **a simple sugar-like molecule.** Under Earth-condition it is the first step in the reaction leading to the formation of ribose (part of RNA). **First detection of a pre-biotic molecule in a solar-type protostar**
- **First determination of acetone abundance, CH_3COCH_3**: Dall'Olio, Thesis @ IT-ARC

Stellar Evolution

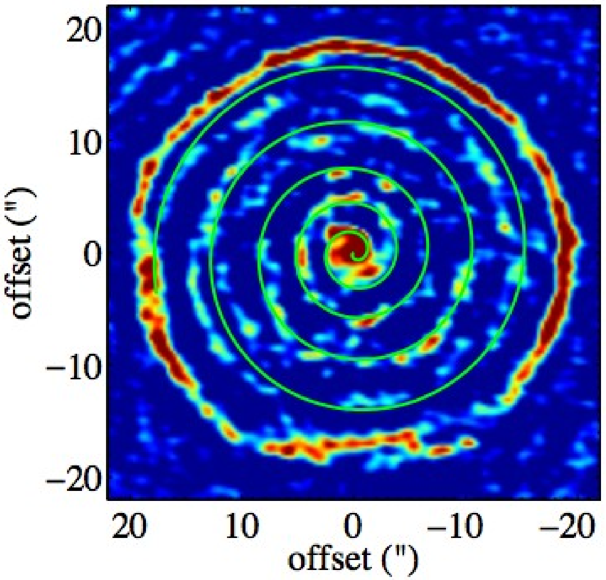
- Imaging of thermal emission from dust in stellar envelopes across the HR diagram
- Spectroscopy of AGB stars (R Sculptoris)
- Imaging of CO flows in post-AGB stars
- Mapping of SN environments (SN1987A)
- High-energy burst details in gamma ray bursts
- ……

PI: M. Maercker

ALMA Observations of AGB Stars – R Sculptoris

R Sculptoris = surrounded by a detached shell of dust and gas, originates from a thermal pulse.
Brief period of increased mass loss!

ALMA CO(3-2), Band 7



CO(3-2) Velocity Channel Movie

OBSERVATIONS

- **Image of molecular shell and circumstellar medium of R Sculptoris with unprecedented detail**
- ~15 antennas, ~4 hrs
- Band 7: CO(3-2), **resolution = 1.3''**
- 45 pointed mosaics (50'' x 50'' field)

Maercker et al. 2012; Vlemmings et al. 2013

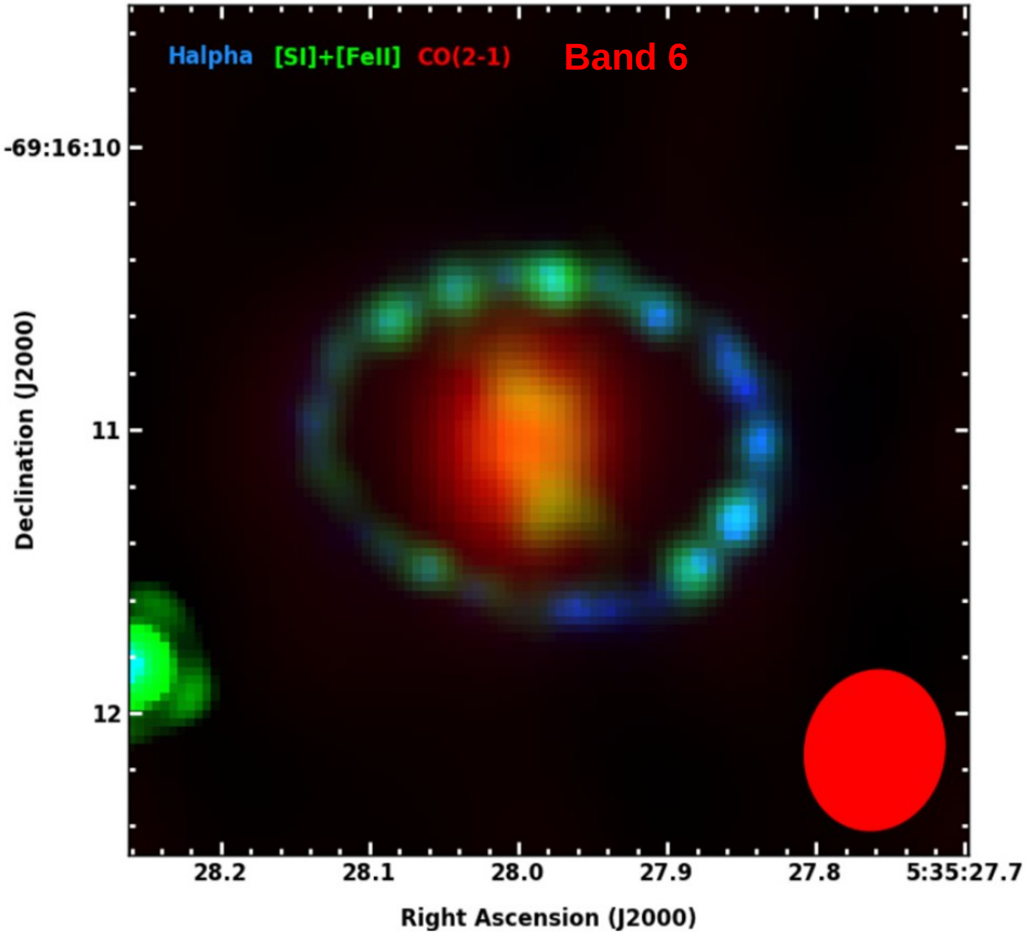
RESULTS

- **Spiral structure in shell: an unseen companion that modulates the loss of mass from the star?**
- Observations + hydrodynamic simulations: a binary system, a thermal pulse about 1800 yr ago lasting ~200 yr
- $\sim 3 \times 10^{-3}$ $M_{\odot}$ of material ejected at v = 14.3km/s, a **mass-loss rate 30 times higher than pre-pulse**
- **~3 times more mass into ISM than previously thought**

PI: R. Indebetouw

CO IN THE COLD DEBRIS OF SUPERNOVA 1987A

SN1987A: unique laboratory to study shock physics and particle acceleration, cosmic dust and element production



OBSERVATIONS

- CO and SiO in the ejecta of SN1987A
- Band 3 (2.6 mm), ~1.5''
- Band 6 (1.3 mm), ~ 0.5''

RESULTS

- Detection from CO(1-0), CO(2-1) and the red wing of SiO(5-4)
- CO(2-1) emission: <1'', located at the center of the debris
- **ALMA + *Herschel*: SN environment filled with cool molecules 25 yrs after the explosion. First such emission detected in a SN remnant!**

Kamenetzky et al 2013

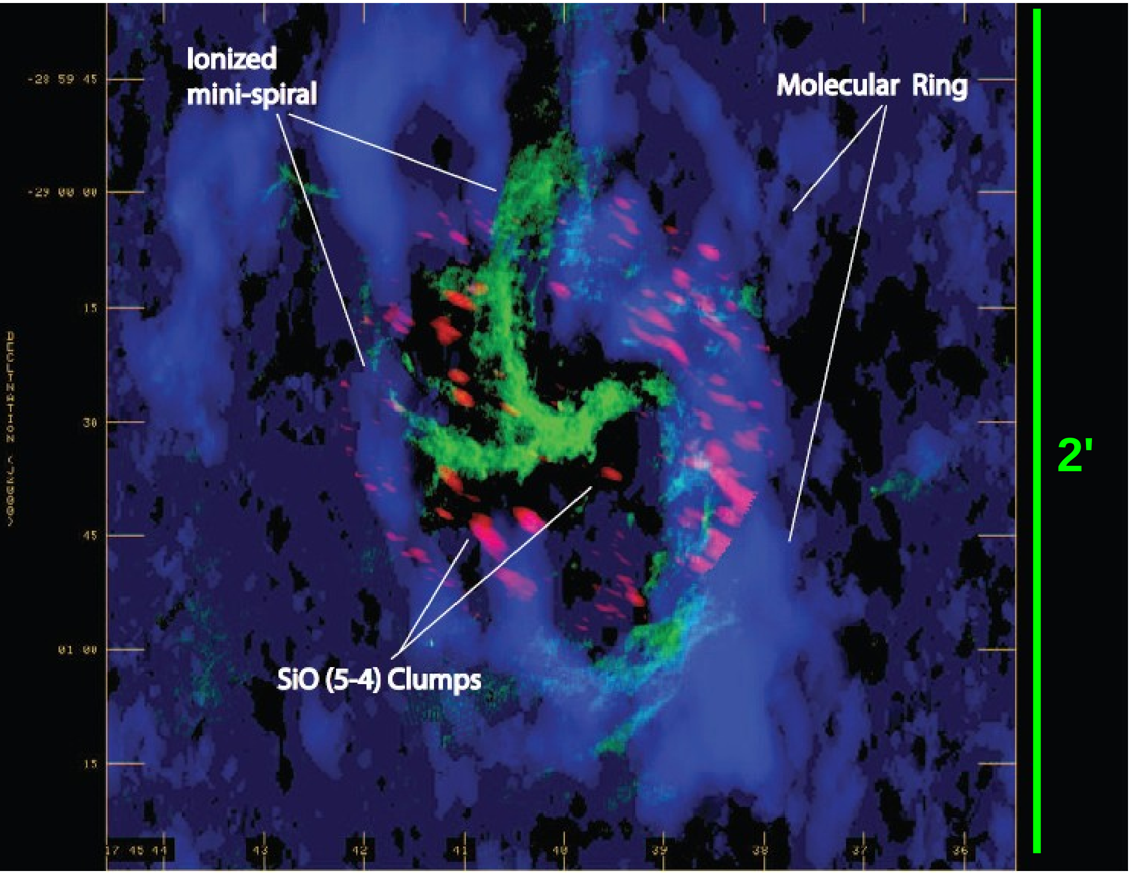
The Local Universe

- Spectroscopy of inner region of MW (Sgr A*)
- AGN feeding and outflows (NGC 1433)
- Physics and chemistry in starburst galaxies (U/LIRGs, NGC 4418)
- Interacting systems (Antennae Galaxies)
- Cooling mechanisms in galaxy cluster cores (Abell 1664, Abell 1835)
- ……

Galactic Center Sgr A*

ALMA is essential to understand the nature of the ISM in the Galactic center, its star formation properties and phenomena near BH.

ALMA Science Verification



Green: VLA 3.6 cm image
Red: ALMA SiO emission
Blue: OVRO HCN(1-0) emission

Yusef-Zadeh et al. 2013

OBSERVATIONS

- 12 x 12m antennas
- 7 point-mosaic at the position of Sgr A*
- **SiO(5-4)**, Band 6
- Spatial resolution ~2''
- Spectral resolution ~3 km/s

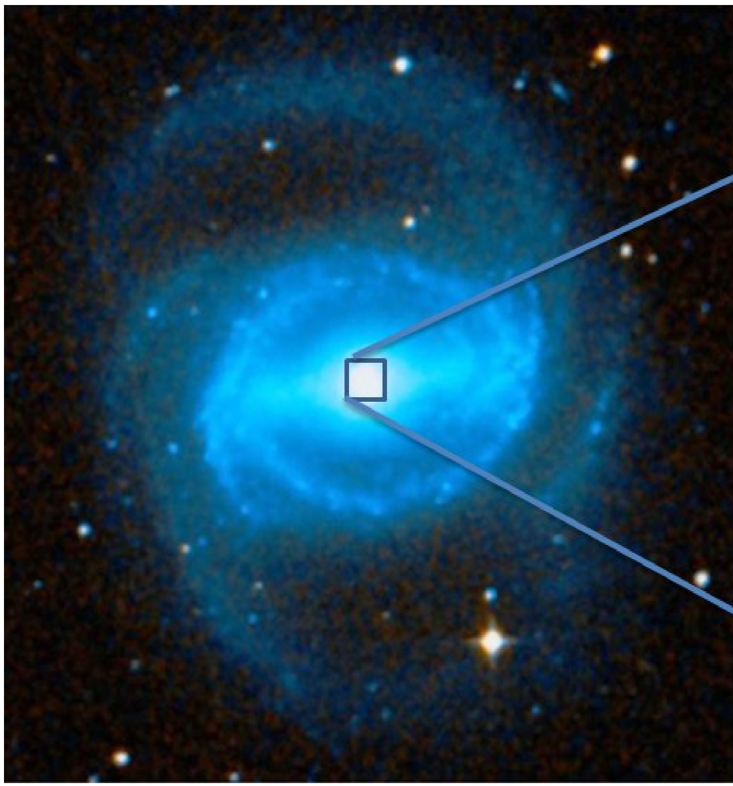
RESULTS

- **Detection of 11 SiO clumps within 0.6 pc (15'') of Sgr A***
- SiO clumps --> embedded protostellar outflows --> an early stage of massive star formation near Sgr A* in the last 10^4-10^5 yr
- **This is the first observation of star formation so close to the galactic center**
- Scientific case for Phasing ALMA for mm-VLBI: "The Event Horizon Telescope"

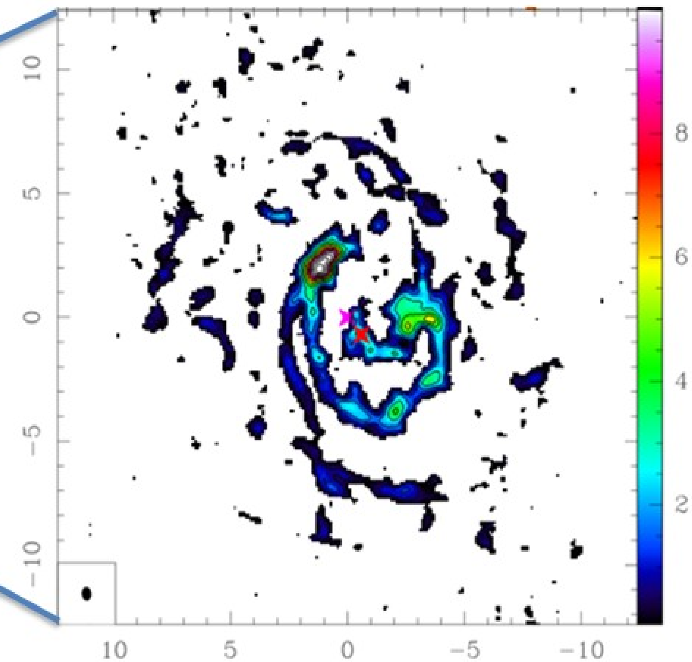
PI: F. Combes

ALMA discovers an outflow of molecular gas in a nearby spiral galaxy: NGC 1433 ("Lord of Rings")

Seyfert 2, strongly barred spiral, D ~ 10 Mpc



CO(3-2) map (~345 GHz, Band 7)



- 19 x 12m antennas
- **CO(3-2), HCO^+(4-3), HCN(4-3)**, Band 7
- Observing time: 2 hours
- 1 pointing: FOV 18" ~ 850 pc
- Spatial resolution 0".56 x 0".42 ~ 24 pc
- Spectral resolution ~0.42 km/s

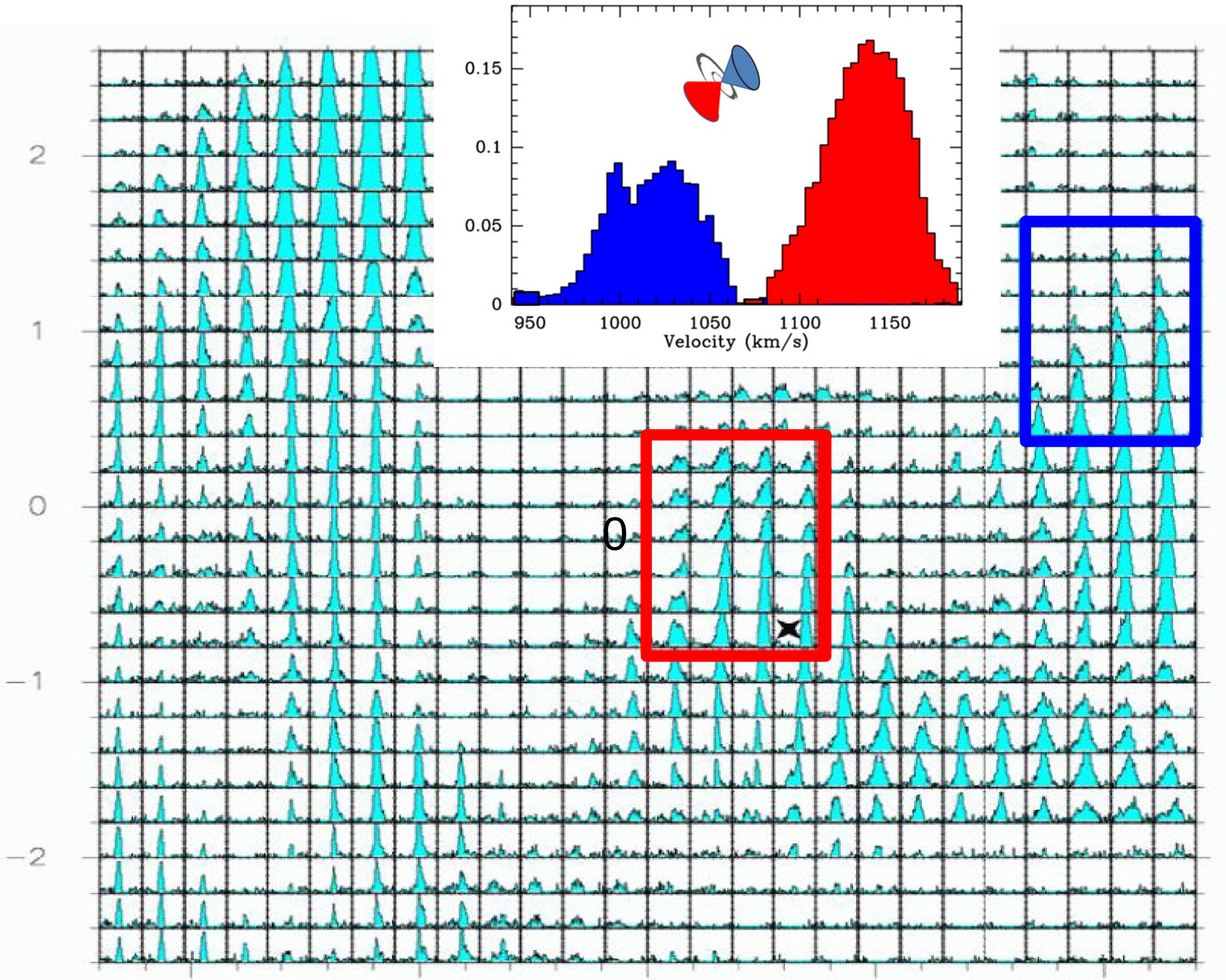
$M(H_2$-18'') ~ 5 x 10^7 $M_\odot$

Nuclear gaseous spiral structure well correlated with the dusty spiral seen in HST. The gas is presently fueling the AGN + molecular outflow

Combes, Garcia-Burillo, Casasola et al. 2013

PI: F. Combes

ALMA discovers an outflow of molecular gas in a nearby spiral galaxy: NGC 1433 (“Lord of Rings”)



CO(3-2) spectra within 2.5'' of the center

The kinematics over the disk reveal rather regular rotation.

1.
near the nucleus an intense high-velocity CO emission feature redshifted to 200 km/s

2.
a blueshifted counterpart at 2'' (100 pc) from the center

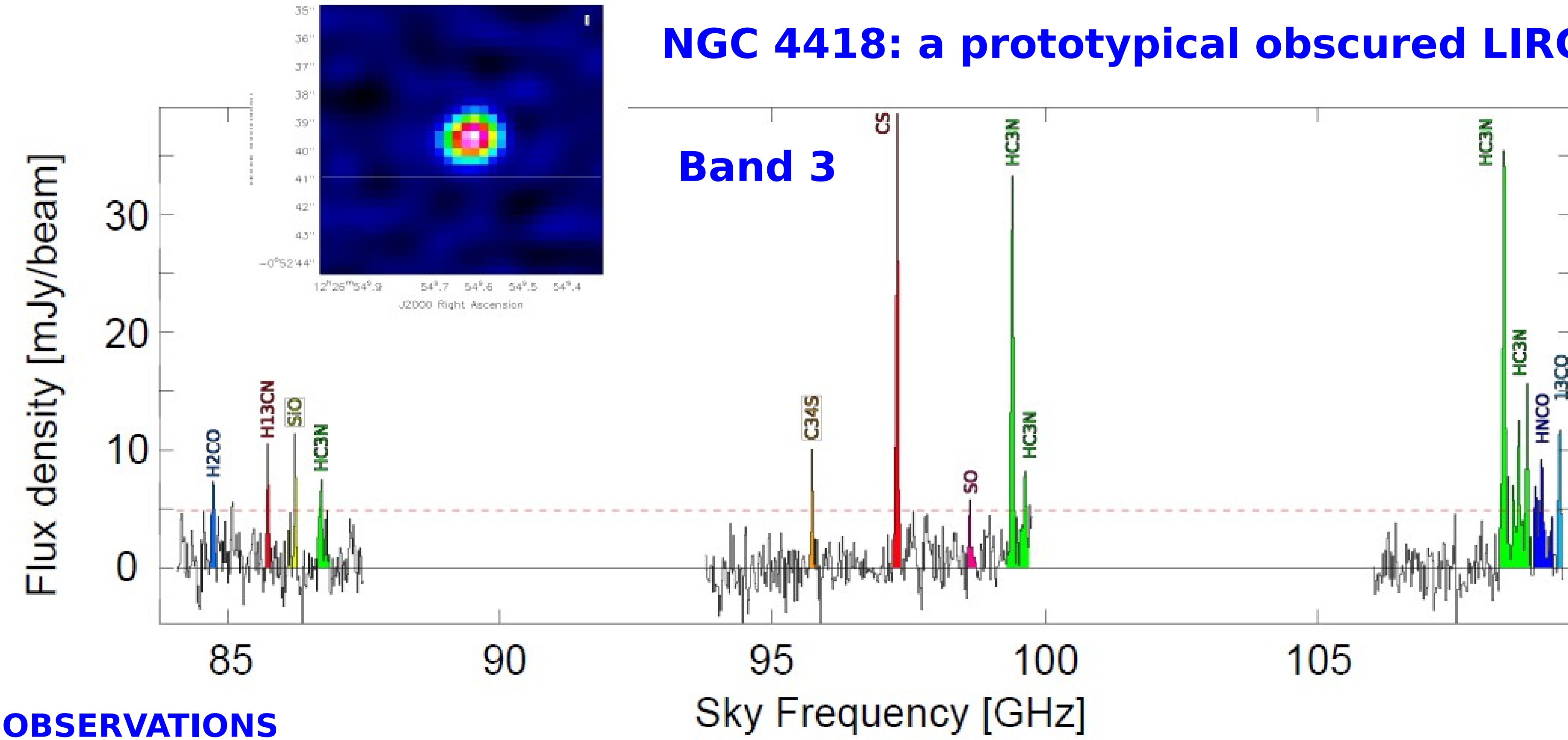
Flow could be mainly boosted by the AGN through its radio jets.
AGN able to remove gas and stop star formation.

Combes, Garcia-Burillo, Casasola et al. 2013

PI: K. Xu PI: S. Aalto PI:F. Costagliola

Compact Obscured Nuclei with ALMA

NGC 4418: a prototypical obscured LIRG



OBSERVATIONS

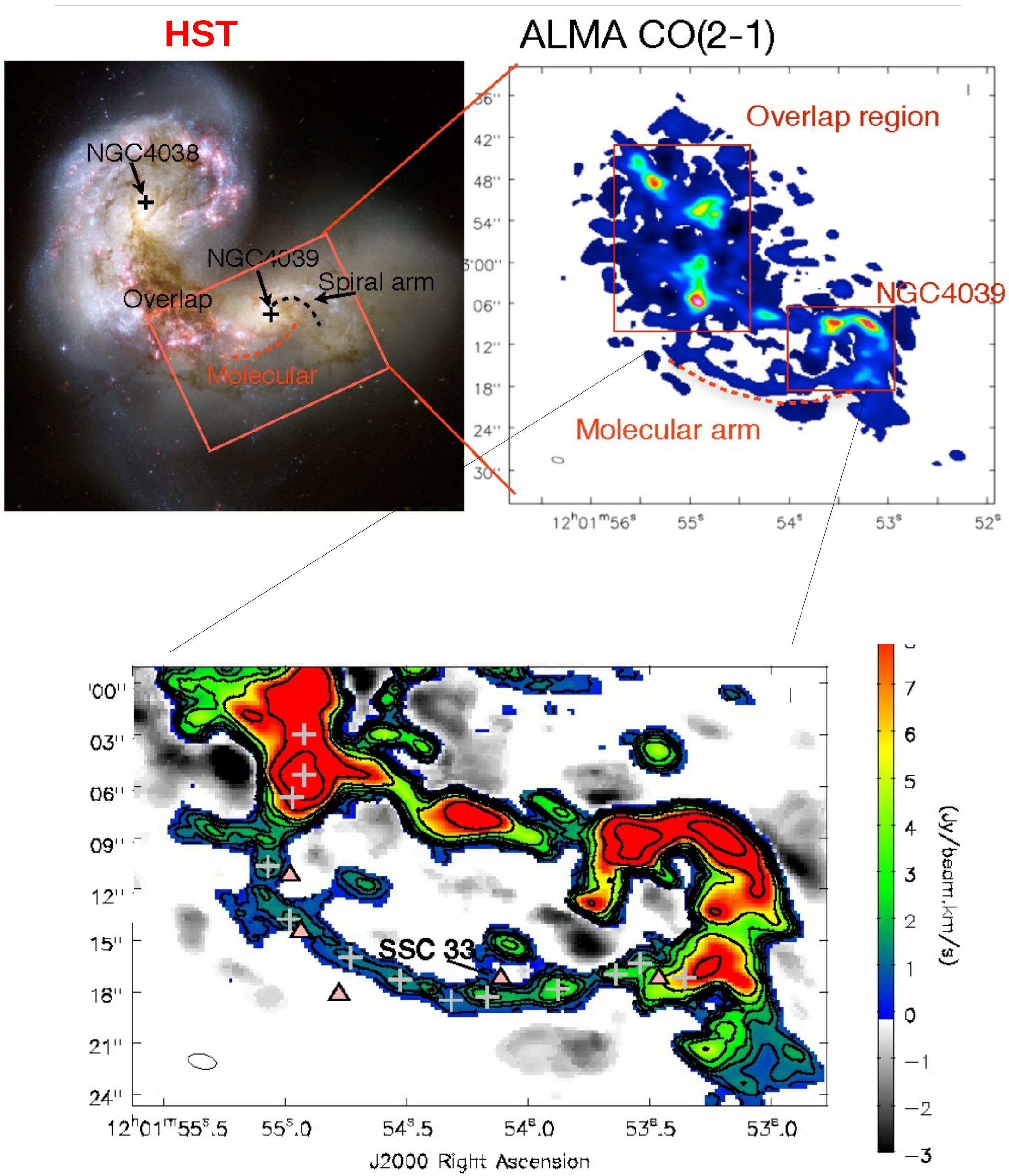
- Several projects on different targets
- 16 antennas
- Lowest spectral resolution
- **In B3: in 5 min on source 14 lines within 8 GHz**
- **170 GHz wide scan in B3, B6 and B7 in < 1 hr 50 lines**

RESULTS

- **NGC 4418: database for physics and chemistry of gas in similar objects**
- ALMA allows to investigate the radiative processes, penetrating the dust
- **Unveil the power-source: starburst or AGN via molecular transitions (CO, HCN, CS...)**

Antennae Galaxies

Study of interacting systems (see also NGC 3256, Sakamoto et al. in preparation)



OBSERVATIONS: Science Verification

- Band 6, 14 antennas
- **Angular resolution ~1.5''**
- 13-17 pointings for NGC4038 and NGC4039
- **rms = 1.2 mJy/beam**

RESULTS

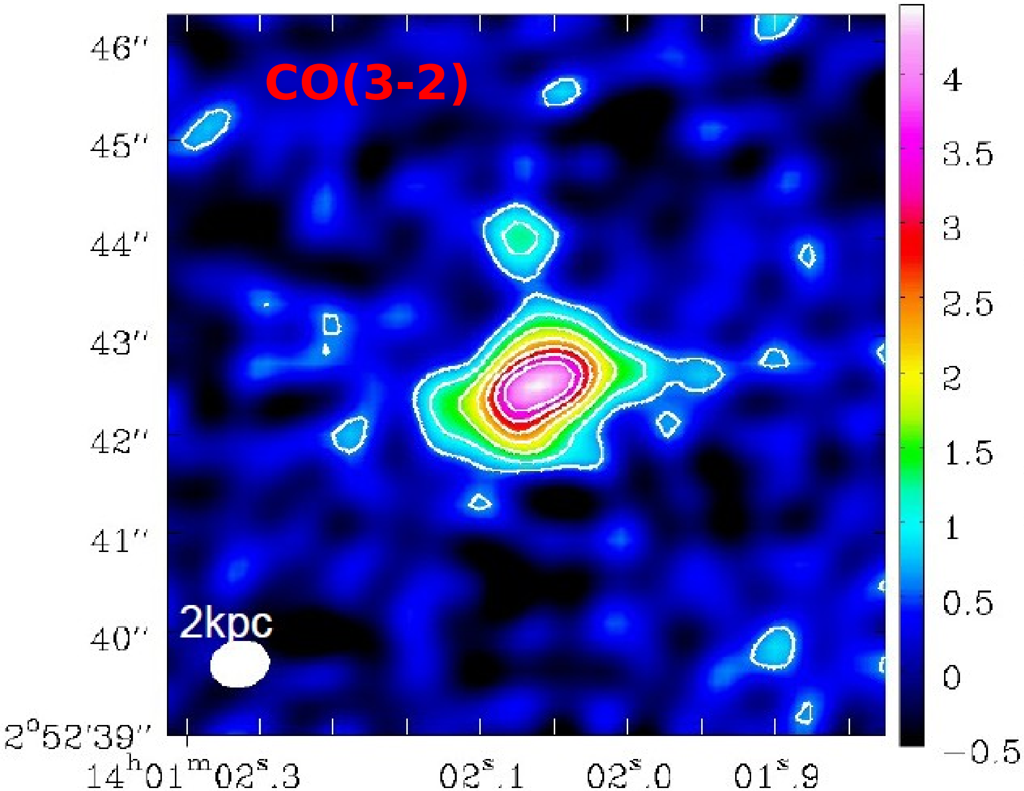
- **Newly discovered tidal arm**: 3.4 kpc long, <200 pc wide, Δv=10-20 km/s
- **~10 clumps of stellar star clusters (SSCs):** most of them unresolved, ~350 pc SSC separation, Mgas ~ 1-8 x $10^6 M_\odot$
- **SFE ~ 10 higher** (log(SFE) ~ -8.2) than in disk galaxies and other tidal arms and bridges
- **The tidal arm morphology is different from that predicted by high-resolution simulations for the Antennae Galaxies**

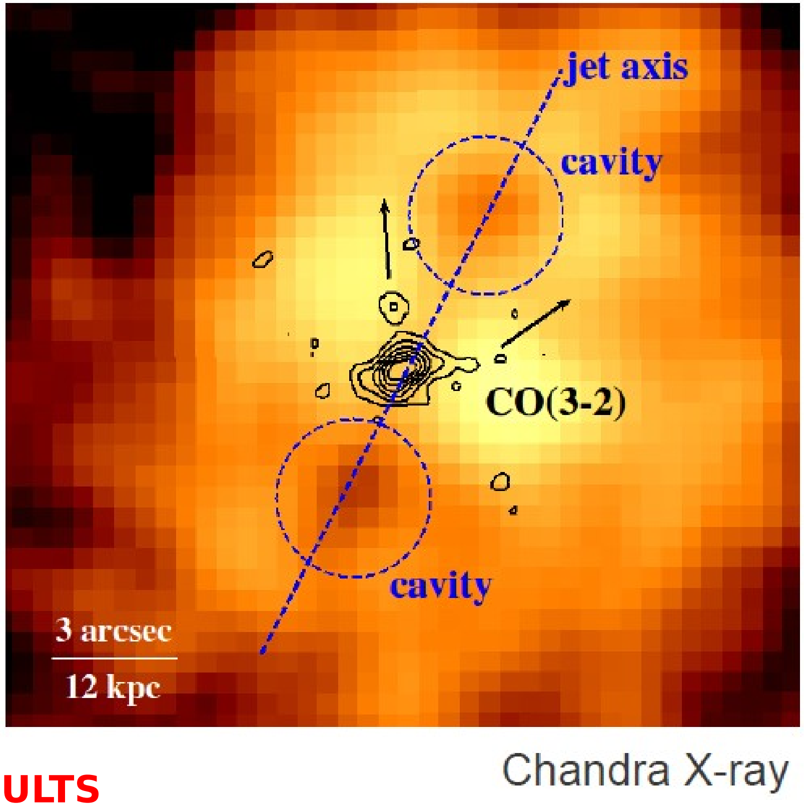
Espada et al. 2012

Russell et al. 2013 McNamara et al. 2013 **PI: B. McNamara**

Molecular Gas in the Cores of Galaxy Clusters

Abell 1835, a prototypical cool core cluster at z=0.25





OBSERVATIONS

- Band 3: CO(1-0) and Band 7: CO (3-2)
- **Angular resolution: 0.5-1.5''**
- 1 hr on source, rms: 0.6-1.6 mJy

RESULTS

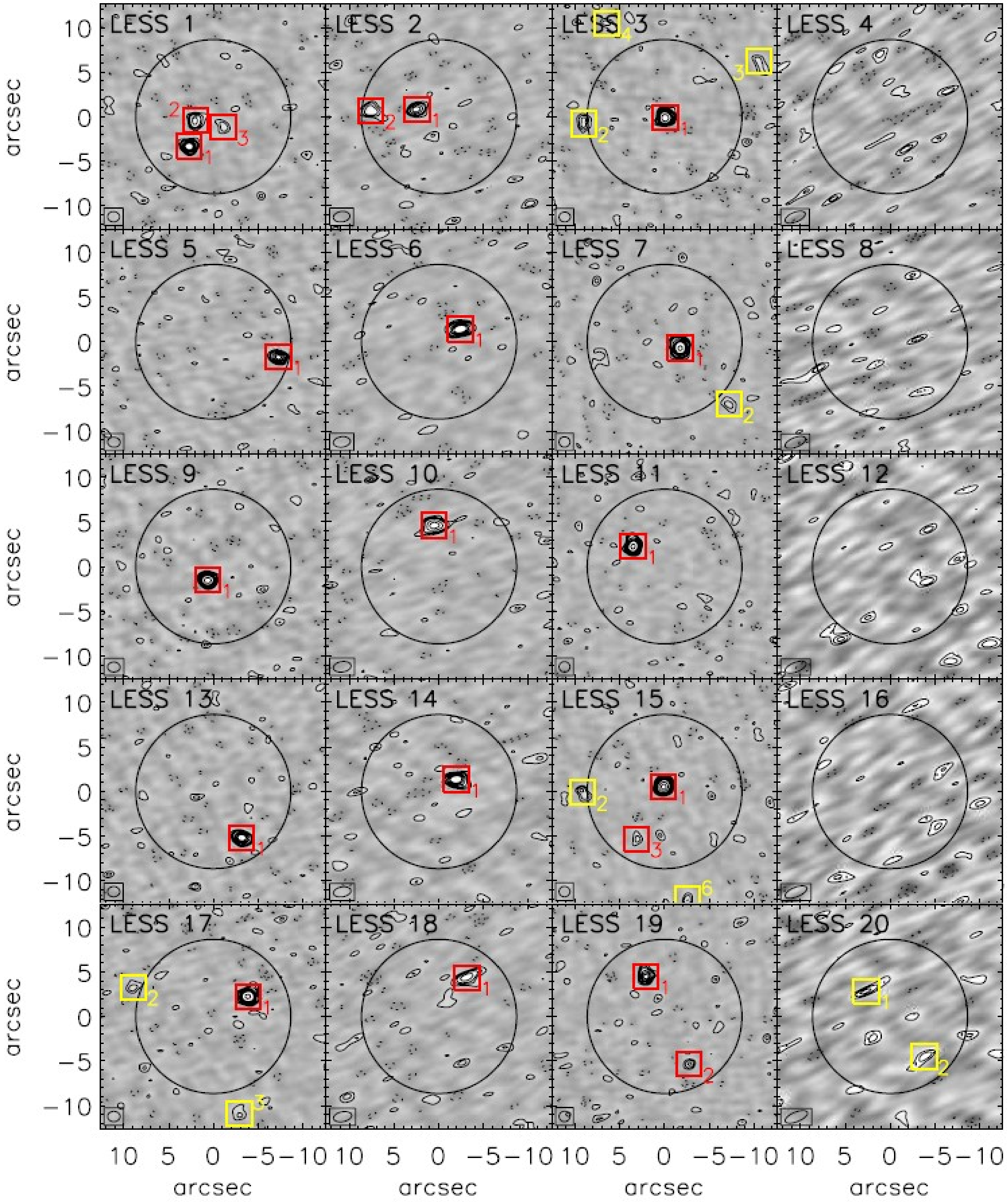
- 5 x 10^{10} $M_\odot$ of molecular gas within 10 kpc of the BCG in a possibly face-on disk
- Gas filaments drawn up or falling back around radio bubbles
- **The radio mode feedback may regulate the amount of molecular gas reaching the nuclei of galaxies.**

Cosmology and the high-z Universe

- Galaxies across the history of the Universe to constrain galaxy formation models
- Submm galaxies near and beyond the peak of the dust emission: star-forming gal. at $z > 1$ exploiting the negative K-correction
- Redshift machine for surveys with other facilities
- Gravitational lensing: magnifies (in flux and size) the observability of “normal” galaxies

PI: I. Smail

An ALMA survey of submm in the Extended Chandra Deep Field South



OBSERVATIONS

- 870 μm (Band 7) follow-up of a LABOCA Extended Chandra Deep Field South Submm Survey (LESS)
- **122 submm sources**
- ~15 antennas, FOV = 17'', **2 min/source**
- rms < 0.6 mJy/beam (**x3 deeper than LABOCA**)
- Resolution ~1.5'' (**x10 better than LABOCA**)

RESULTS

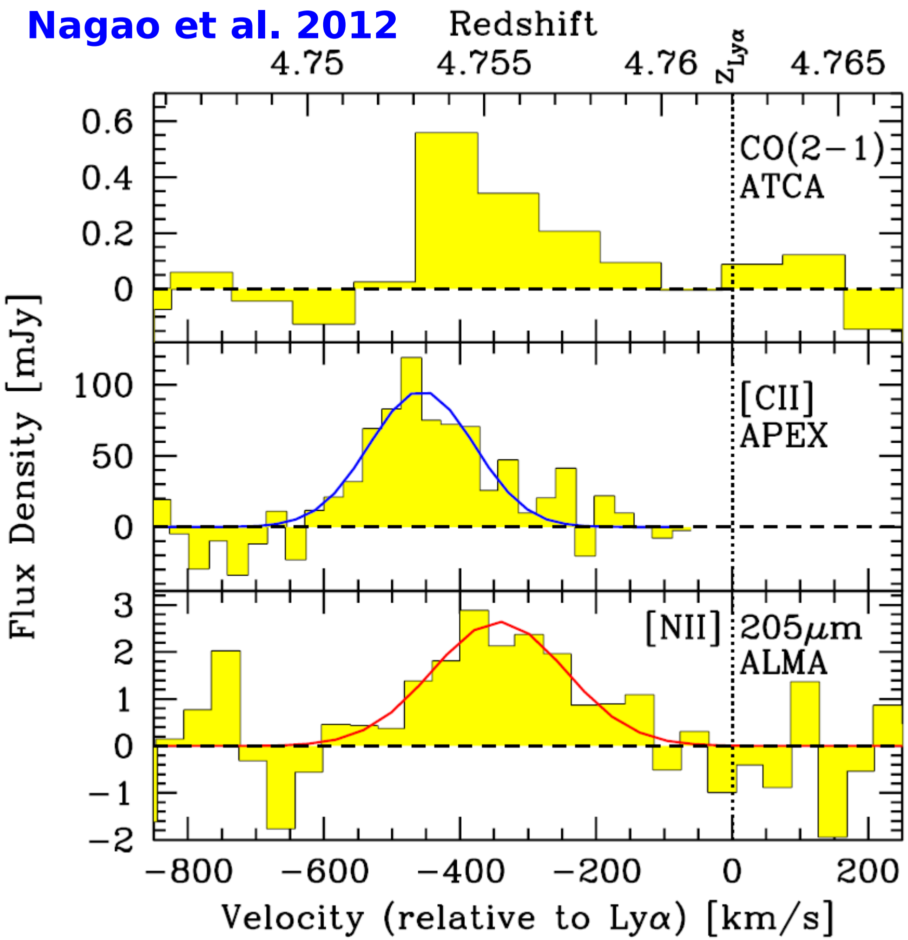
- ~35% of the detected LABOCA sources are resolved in multiple SMGs
- In 2 SMGs detection of [CII] 158 μm at z ~ 4.4 **ALMA able to detect the dominant fine-structure cooling lines with short integration**
- **Selections in radio/mid-IR bands miss 45% of SMGs**
- **First statistically survey of SMGs: basis for an unbiased multifrequency study of SMGs**

Hodge et al 2013; Karim et al. 2013; Swinbank et al. 2013, and many other papers ….

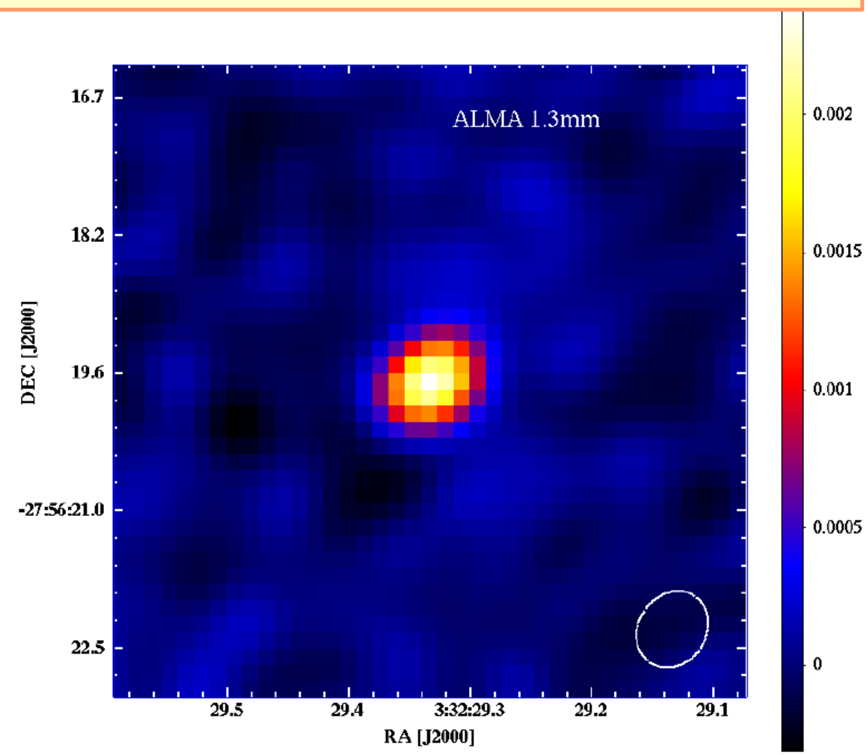
PI: R. Gilli PI: C. De Breuck

ALMA reveals a chemically evolved SMG at z = 4.76

Nagao et al. 2012



- [CII]-emitting SMG LESS J033229.4-275619 at z = 4.76
- Band 6, 250 GHz, 18 antennas, 3.6 hrs, 1.5'' res (PI: De Breuck)
- [NII] 205 μm detection: [NII] arises from HII regions (Nagao et al 2011)
- **The first measure of [NII]/[CII] in high-z galaxies**, ~0.043, similar to the nearby Universe
- [NII]/[CII] metallicity indicator: as the metallicity in this SMG is consistent with solar, **the chemical evolution has progressed very rapidly**



- Band 6, 1.3 mm continuum, 17 antennas, 23 min (including cal.), 0.75'' res (PI: Gilli)
- **Dust temperature Tdust ~ 60 K with ALMA + Herschel**
- Warm and compact starburst surrounds an obscured BH

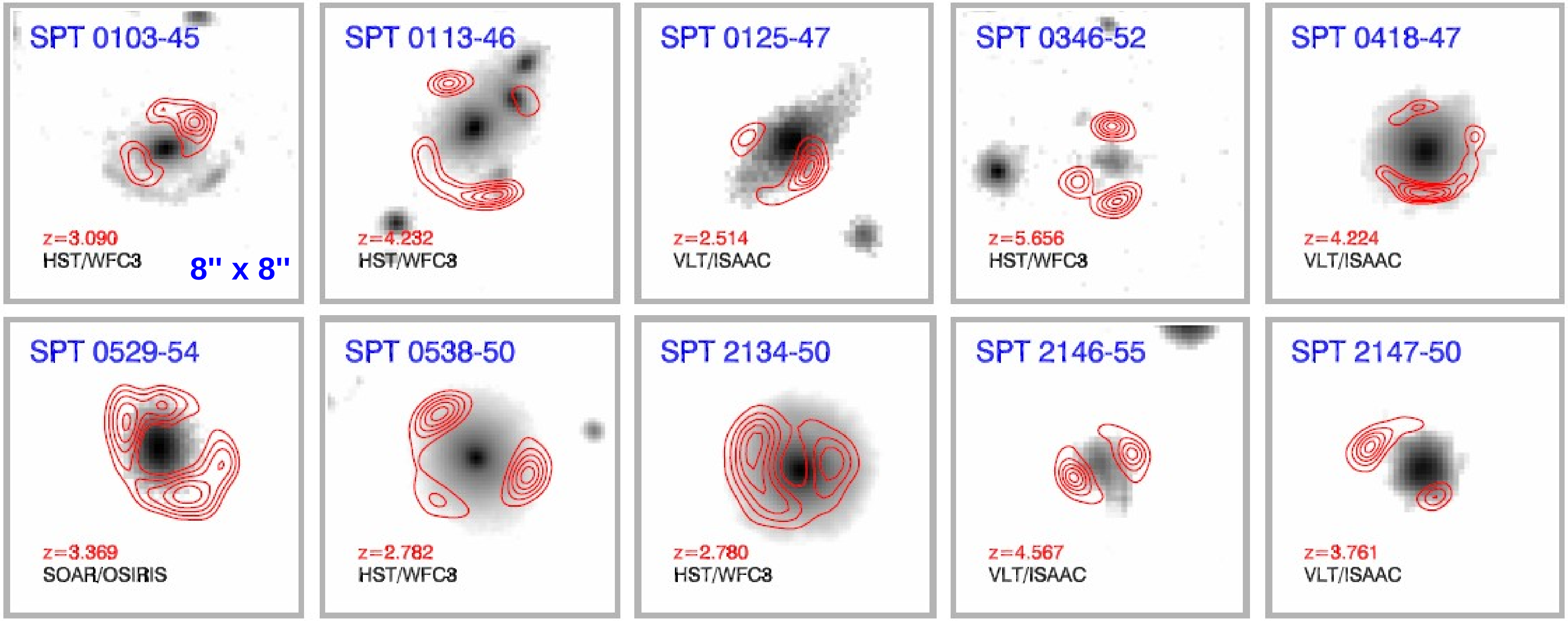
Gilli et al submitted – Supported by Italian ARC

Hezaveh et al 2013; Vieira et al 2013; Weiss et al. 2013

PI: D. Marrone

ALMA Observations of SPT Discovered, Strongly Lensed, Dusty, star-forming Galaxies

NIR Images + ALMA (Band 7) 870 μm Contours



OBSERVATIONS

- Catalog of z > 1 strongly gravitationally lensed sources sampled from the South Pole Telescope (SPT) survey
- 47 SMGs detected with SPT, F(1.4 mm) > 20 mJy
- ~15 antennas, ~4 hrs (**~80 sec/source**)
- Band 3 (spectroscopy) and Band 7 (imaging)
- Resolution ~ 1.5''

RESULTS

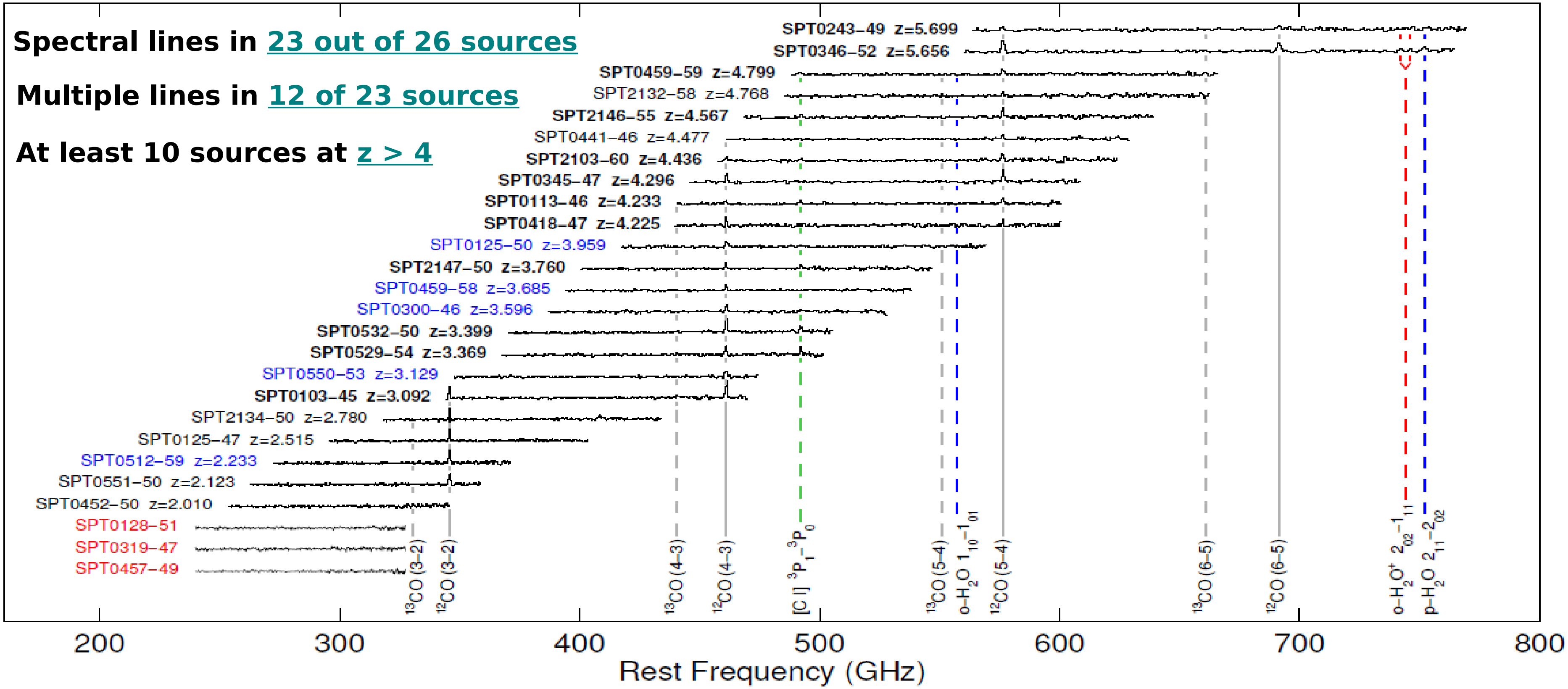
- **Multiple images**, separated by 1-3'': **consistent with strong lensing**
- Magnification Factors: 4-22
- Lensed sources = ultra luminous starburst galaxies at high z
- **ALMA allows to image lensed galaxies obscured in NIR/optic where the lens dominates the emission**

ALMA Observations of SPT Discovered, Strongly Lensed, Dusty, star-forming Galaxies

Vieira et al 2013

First spectroscopic redshift survey with ALMA

ALMA Cycle 0 Band 3
100 GHz compact configuration
26 sources
5 tunings in the 3 mm band
10 minutes per source



Bold = unambiguous redshift from ALMA

black = single lines with ALMA, confirmed with C+ or CO(1-0) with APEX or ATCA

blue = single line detected with redshift, most likely redshift from photo-z

red = no line detected

… ALMA Cycle 2 …

Cycle 2: Capabilities

Antennas: **34x12m Main Array + (9x7m + 2x12m-TP) ACA**
ACA only to complement main array observations

Receiver Bands: **Bands 3, 4, 6, 7, 8 & 9** (~3.1, 2.1, 1.3, 0.87, 0.74, and 0.44 mm)

Type of observation: Single field interferometry and mosaics

Spectral line: all Arrays (except in Band 9 with TP array)

Continuum: all Arrays

Configurations: Bands 3, 4, 6 & 7: **160-1500m (up to 0.11'')**
Bands 8 & 9: **160-1000m (up to 0.08'')**

Polarization: **Single + Dual in all Bands**
Full only main Array, continuum, B3, B6, B7, no ACA, no mosaics
Sources must have angular scale < 1/3 primary beam$_{\text{12-m Array}}$
(3hr observations for calibration issues)

Spectral scan: **Spectral survey or redshift searches** available on main Array

Declination: Shadowing Problem:
Main Array: NO Dec < -75 deg, Dec > +25 deg (especially in compact config.)
ACA: NO Dec < -60 deg, Dec > +20 deg

Cycle 2: Limitations & Info

Pointing: ≤ 150 pointings in the same Science Goal (single pointings or mosaic pointings).
Individual pointings separated <10° and with the same spectral setup

Observing Time: **≤ 100 hrs per proposal** as estimated by Observing Tool

Moving Targets but No solar observations
(ToO and DDT allowed)

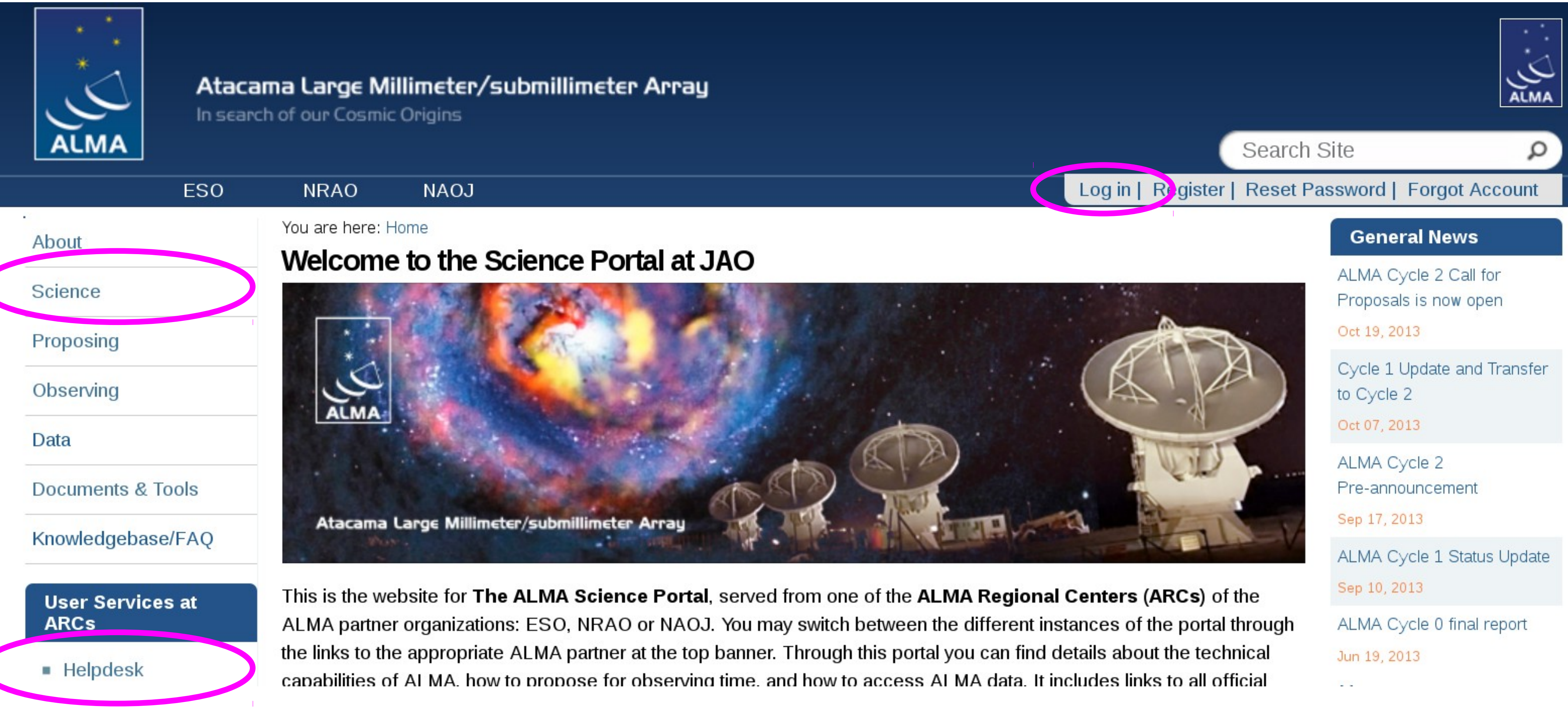
2000 hrs for Cycle 2 and highest priority Cycle 1 projects transferred to Cycle 2

Cycle 2 Observations: from June 2014 to October 2015

Deadline: 15:00 UT on December 5, 2013

ALMA Science Portal

http://almascience.eso.org/



Get support for Cycle 2 from the Italian node!

For your proposals, data reduction with CASA and ALMA related stuff contact us and/or organize your visit to the Italian ARC node

- 3 visitor stations available
- 1 ARC node member dedicated to each visitor
- 10 TB disk space available during your visit + 3 month for download

Enjoy your ALMA Cycle 2 proposal!

Deadline: 15:00 UT on December 5, 2013

Grazie!