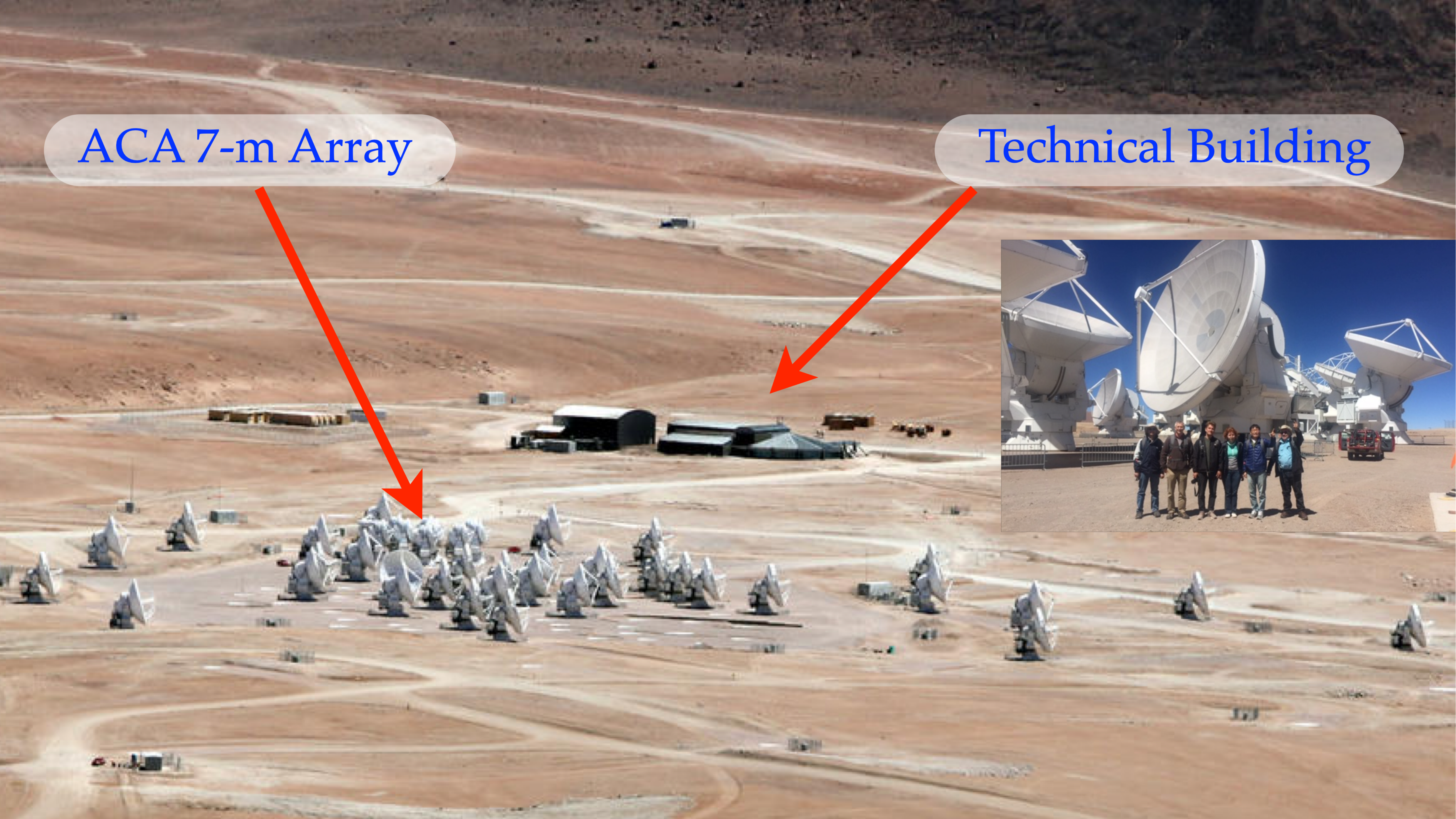
# ALMA Science Highlights

Jongsoo Kim

ALMA Town-hall meeting at KASI

March 20, 2019


ACA 7-m Array
Technical Building

# ALMA Full Operations Specifications

| | Specification |
|---|---|
| *Number of Antennas* | *50×12 m (12-m Array), plus 12×7 m & 4×12 m (ACA)* |
| *Maximum Baseline Lengths* | *0.16 - 16 km* |
| *Angular Resolution (")* | *~0.2" × (300/ν GHz) × ( 1 km / max. baseline )* |
| *12 m Primary beam (")* | *~20.6" × (300/ν GHz)* |
| *7 m Primary beam (")* | *~35" × (300/ν GHz)* |
| *Number of Baselines* | *Up to 1225 (ALMA correlators can handle up to 64 antennas)* |
| *Frequency Coverage* | *All atmospheric windows from 84 GHz - 950 GHz (with extension to ~30 GHz when Band 1 is deployed)* |
| *Correlator: Total Bandwidth* | *16 GHz (2 polarizations × 4 basebands × 2 GHz/baseband)* |
| *Correlator: Spectral Resolution* | *As narrow as 0.008 × (300/ν GHz) km/s* |
| *Polarimetry* | *Full Stokes parameters* |

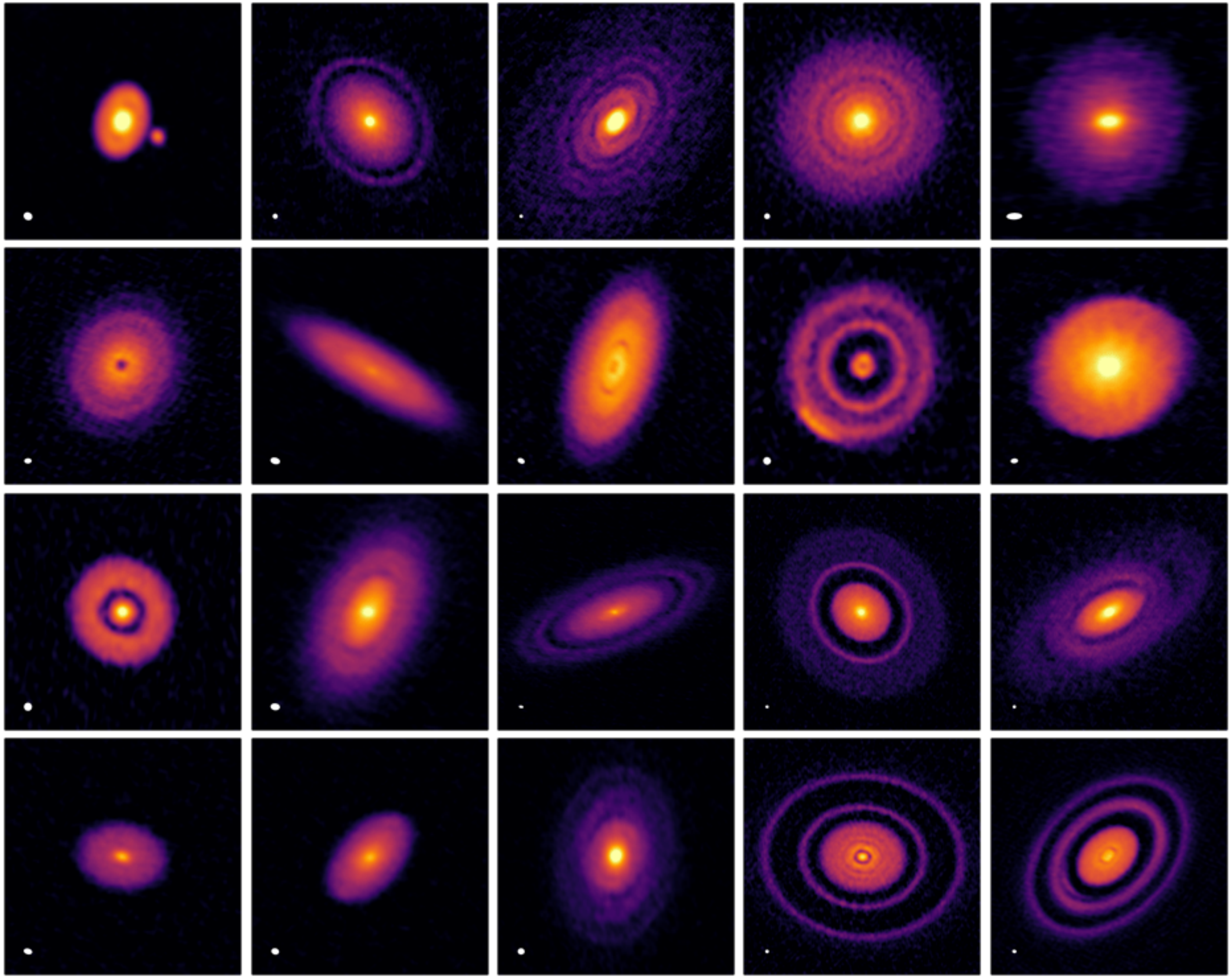
# Level One Science Aims

- The ability to detect spectral line emission from CO or $C^+$ in a normal galaxy like the Milky Way at a redshift z=3, in less than 24 hours of observation.
- The ability to image gas kinematics in a solar-mass protostellar / protoplanetary disk at a distance of 150 pc, enabling one to study the physical, chemical, and magnetic field structure of the disk and detect the tidal gaps created by planets undergoing formation.
- The ability to provide precise images at an angular resolution 0.1".

→ ASAC reported that the aims were essentially achieved for the last five Cycles.

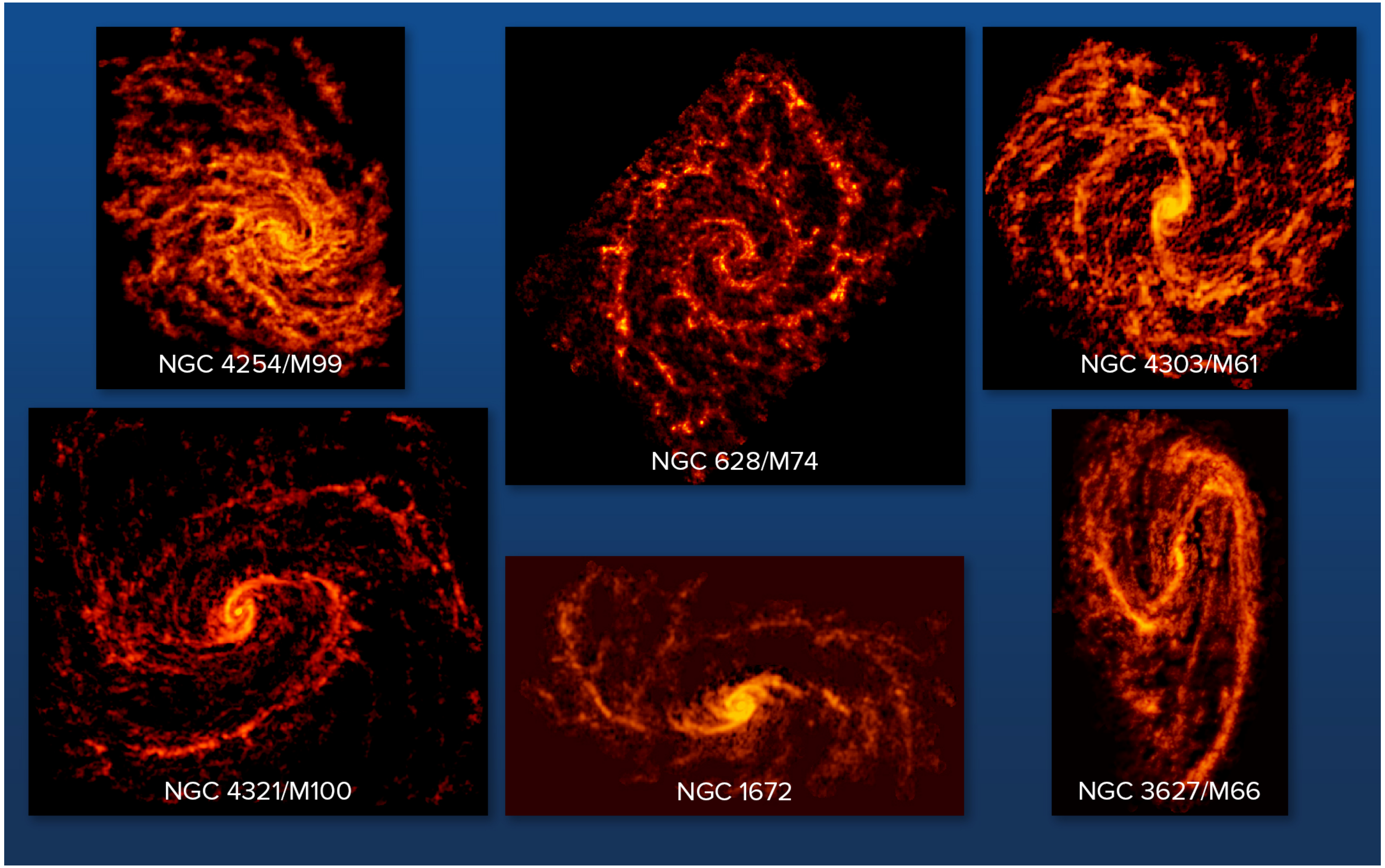
# DSHARP

- Cycle 4 LP
- High-resolution (35 mas) survey of 240 GHz (1.25mm) continuum and $^{12}CO$ J=2-1 emission from 20 nearby PPDs
- 10 articles published in ApJL focus issue



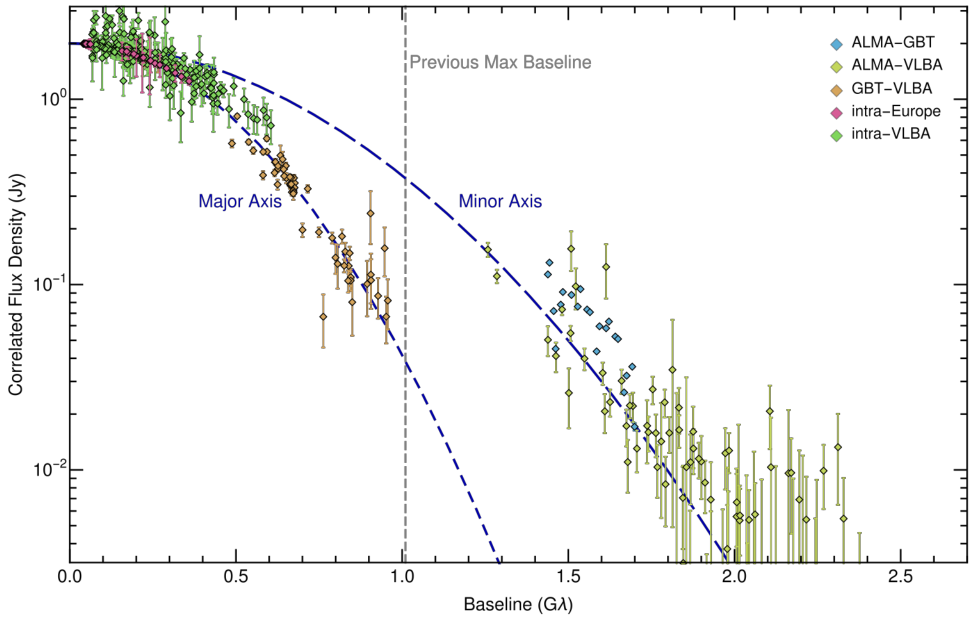
# PHANGS; Cycle 5 LP
## (Physics at High Angular Resolution in Nearby GalaxieS)

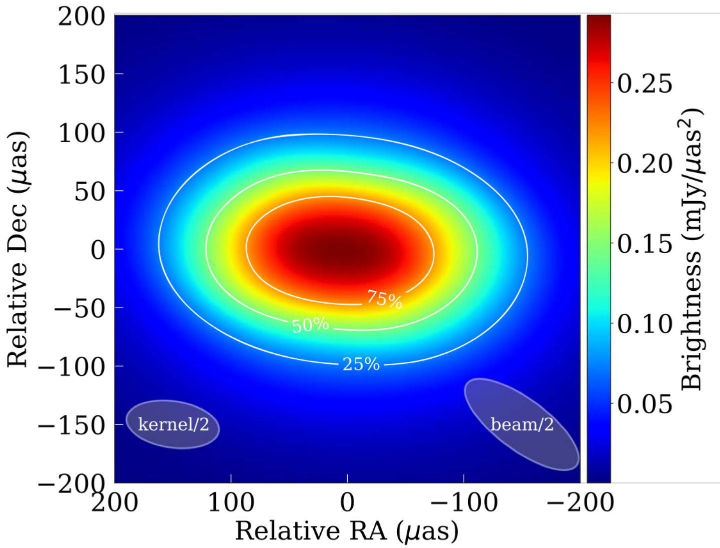
- 74 galaxies; 750h ALMA time
- Understand star formation changes on the size, age, and internal dynamics

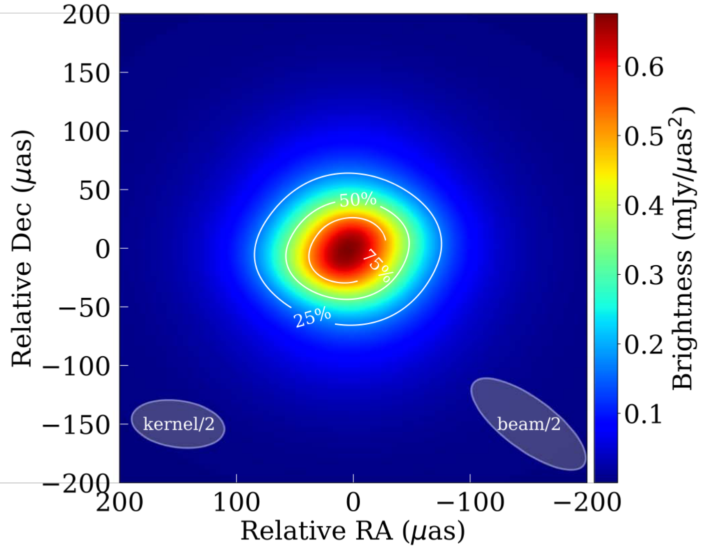


# Sgr A*, First VLBI with ALMA

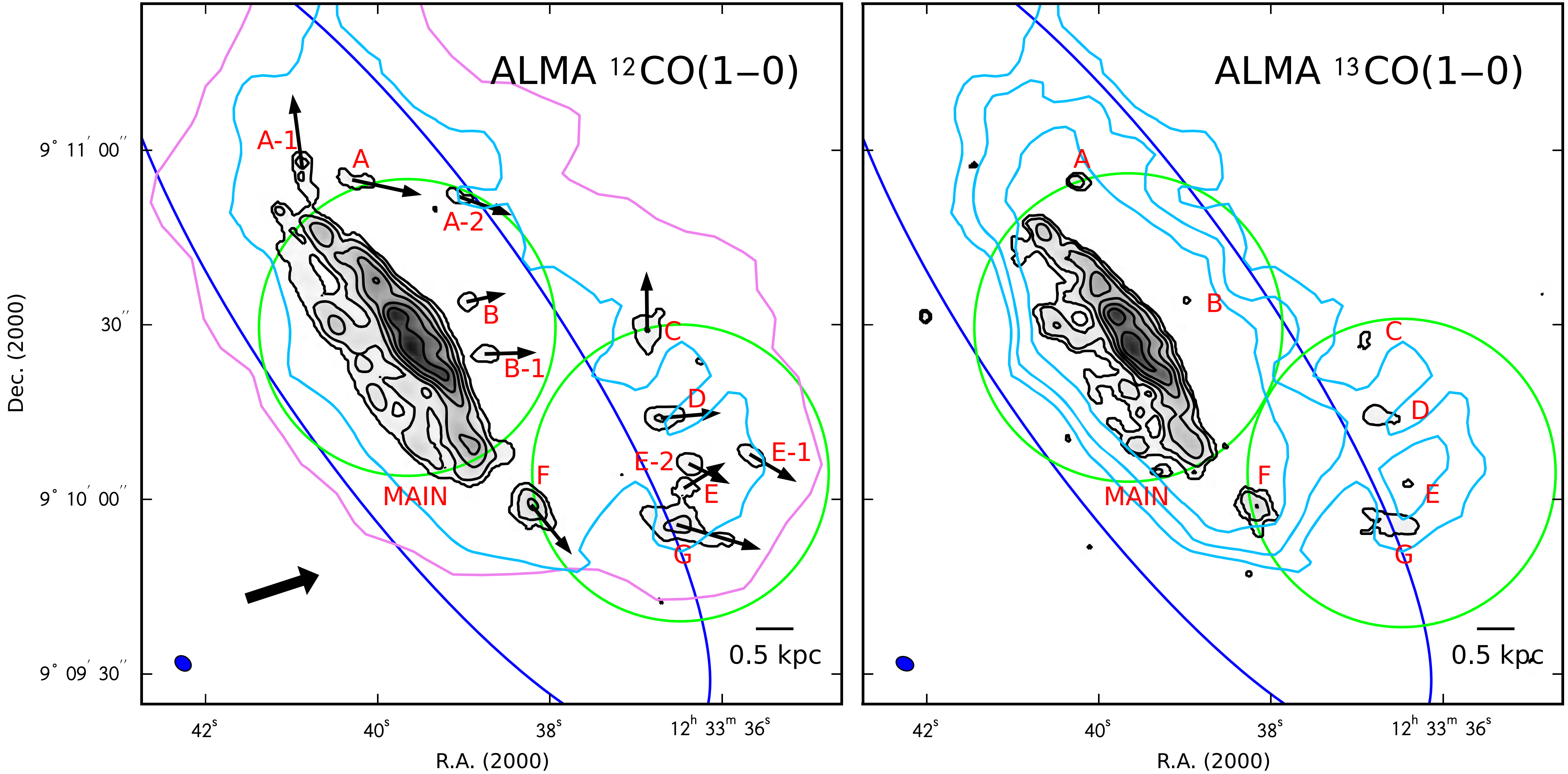
- 2019, ApJ, Issaoun+ (조일제, G.-Y. Zao)
- GMVA (VLBA,GB,YS,PV,EB)+ALMA(37 phased antennas) at 86 GHz (3.5mm), 5.76h integration time with ALMA
- 87 μas (factor of 2 improvement)
- Unscattered source has a major-axis size of 120 μas (12 μas Schwarzschild radii)



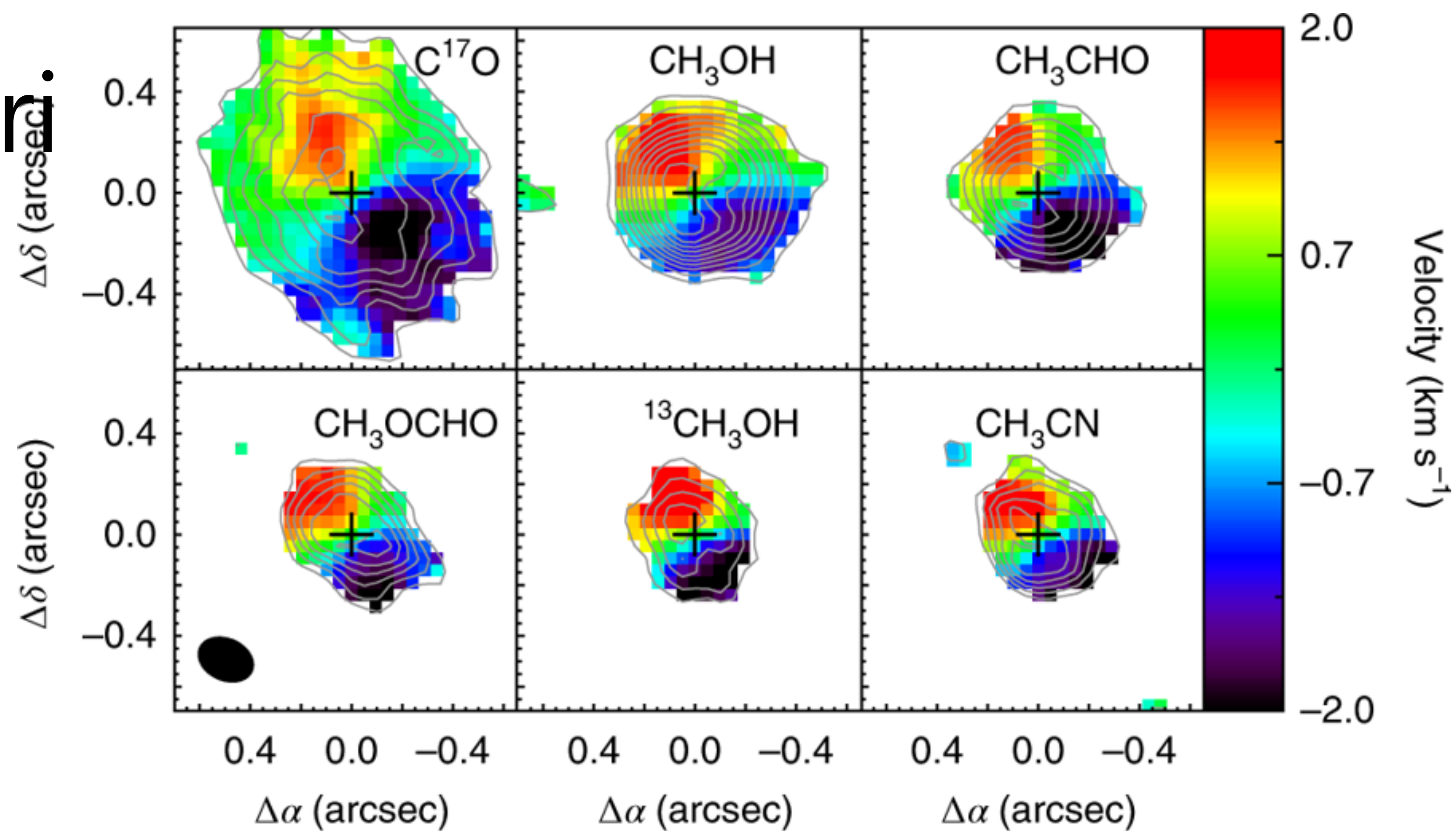



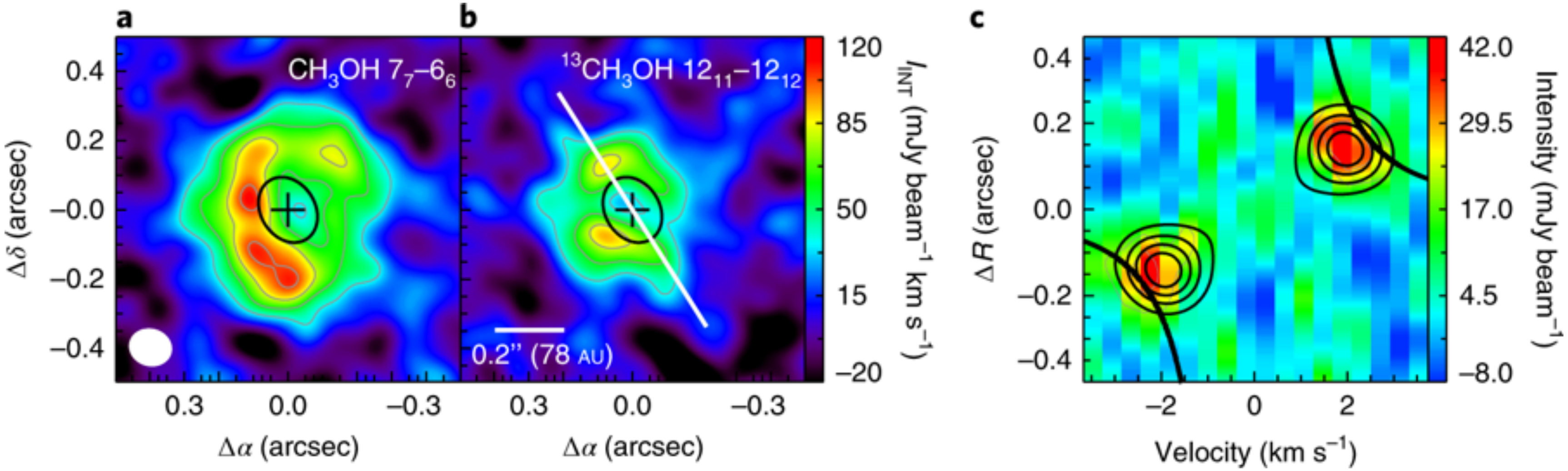
# Extraplannar $^{13}$CO in a Ram-pressure-stripped Galaxy 이범현+정애리 2018, ApJL



# COMs in V883 Ori
## 이정은+, 2019, NA

- V883 Ori, A FU Ori stat with mass of 1.2 Msun
- ALMA band 7, 0.03″ continuum, 0.2″ for COM emission

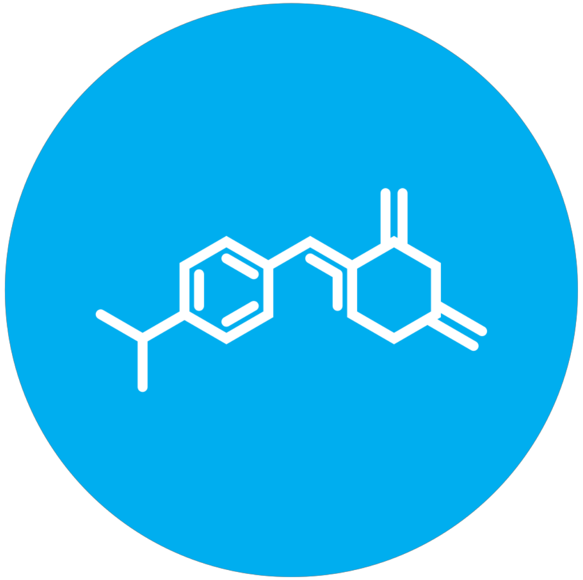


# ALMA Development Roadmap

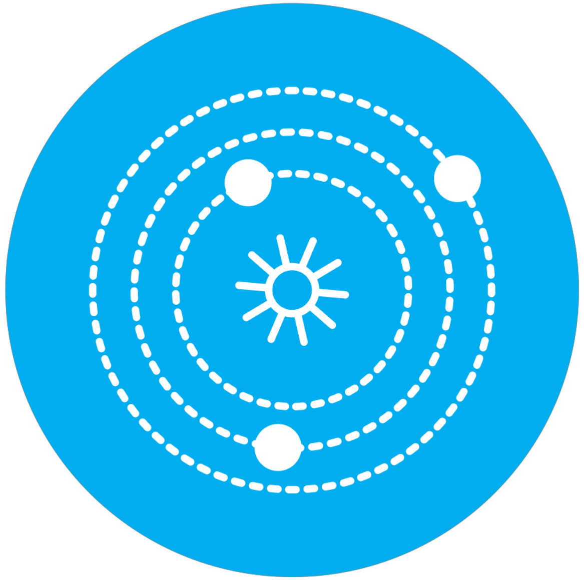
## ORIGINS OF GALAXIES

Trace the cosmic evolution of key elements from the first galaxies (z>10) through the peak of star formation (z=2–4) by detecting their cooling lines, both atomic ([CII], [OIII]) and molecular (CO), and dust continuum, at a rate of 1-2 galaxies per hour.



## ORIGINS OF CHEMICAL COMPLEXITY

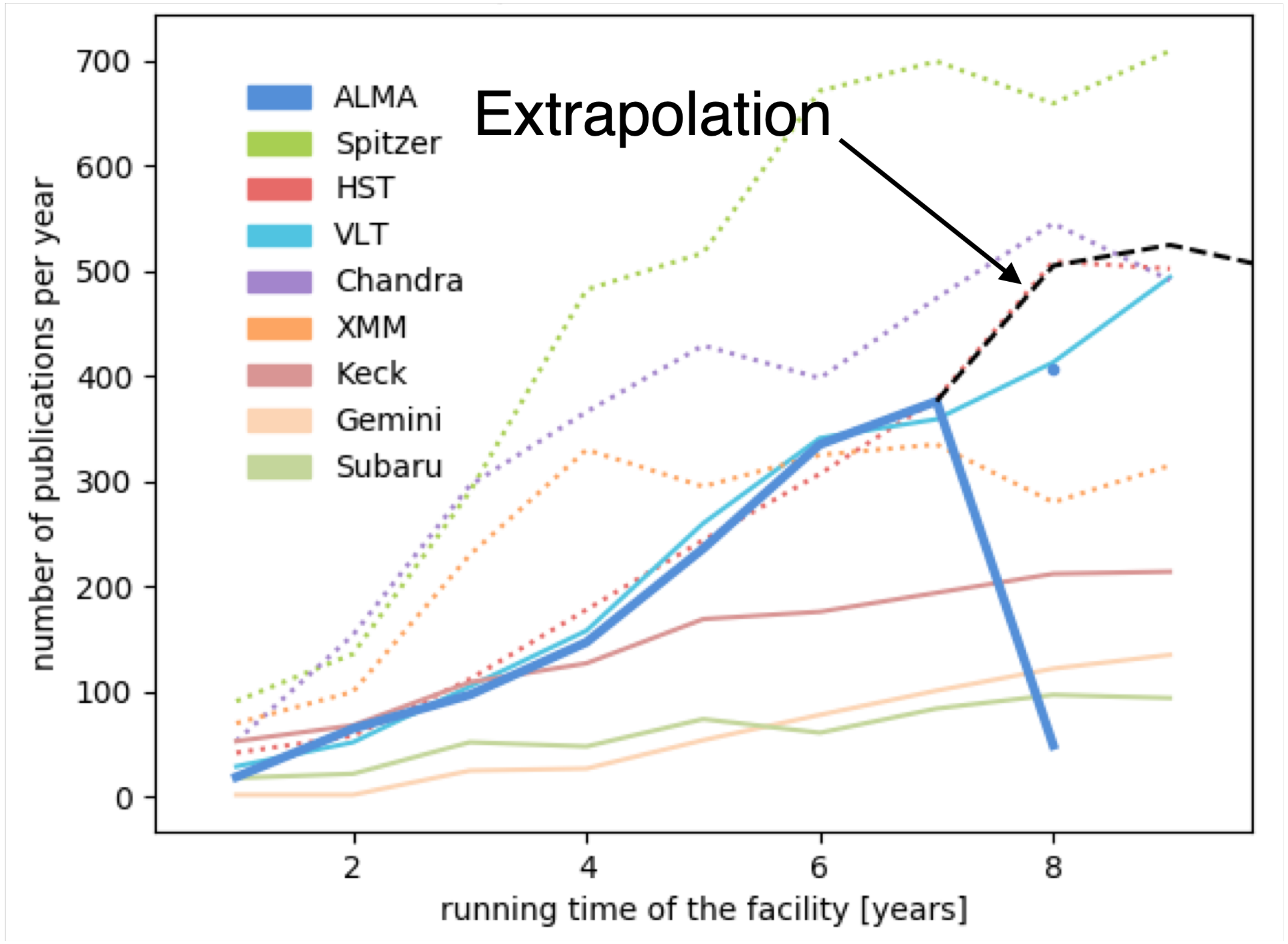
Trace the evolution from simple to complex organic molecules through the process of star and planet formation down to solar system scales (~10-100 au) by performing full-band frequency scans at a rate of 2-4 protostars per day.



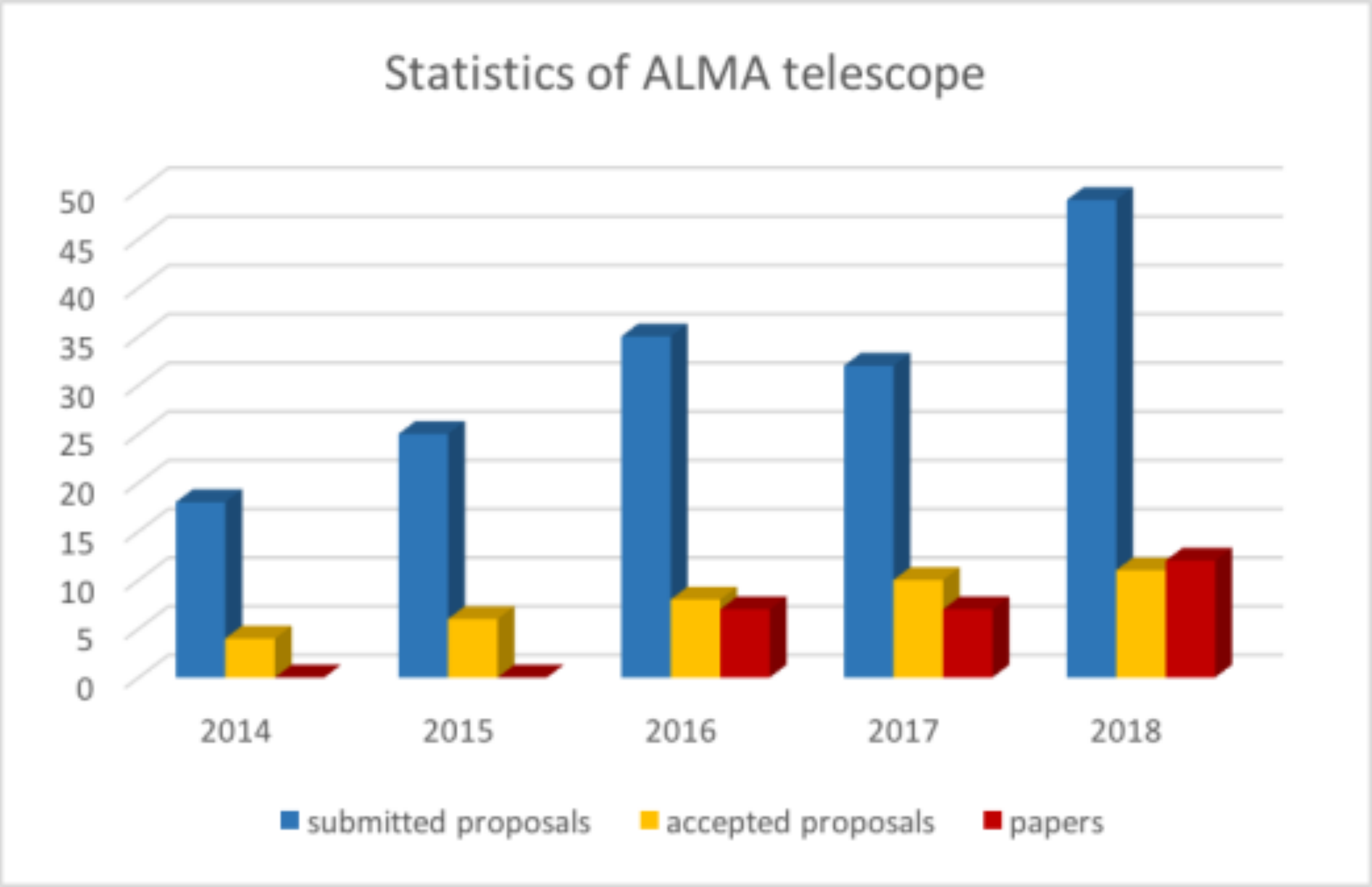
## ORIGINS OF PLANETS

Image protoplanetary disks in nearby (150 pc) star formation regions to resolve the Earth forming zone (~ 1 au) in the dust continuum at wavelengths shorter than 1mm, enabling detection of the tidal gaps and inner holes created by planets undergoing formation.

# ALMA paper productivity



# ALMA proposals and papers




- '17→ '18
- Submitted proposal: 32→49
- Accepted proposal: 10→11
- Published paper: 7→13