ALMA-SPICA Synergy

(ALMA: Atacama Large Millimeter/Submillimeter Array)

Masao Saito (ALMAJ/NAOJ)

Synergy

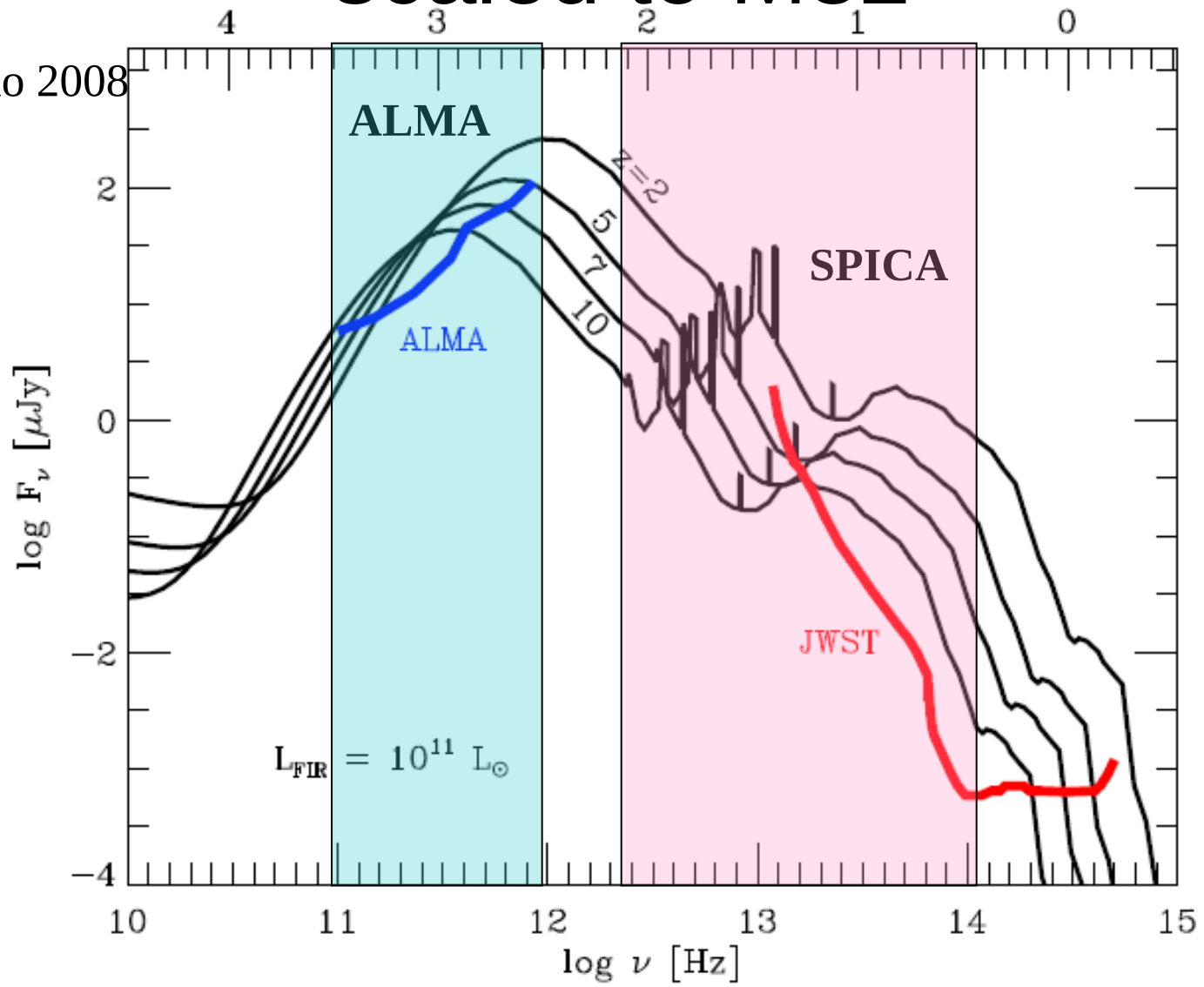
- Synergy is additional effectiveness when two work together.
- Synergy is not easy!
- Results are unpredictable!
  - Very Large Array : A quarter of its time during its initial decade of operation on the key science drivers listed in the funding proposal.
- Try Analytic Continuation
  - Science :

  Early Universe, Interstellar Matter, Planetary System
  - System :

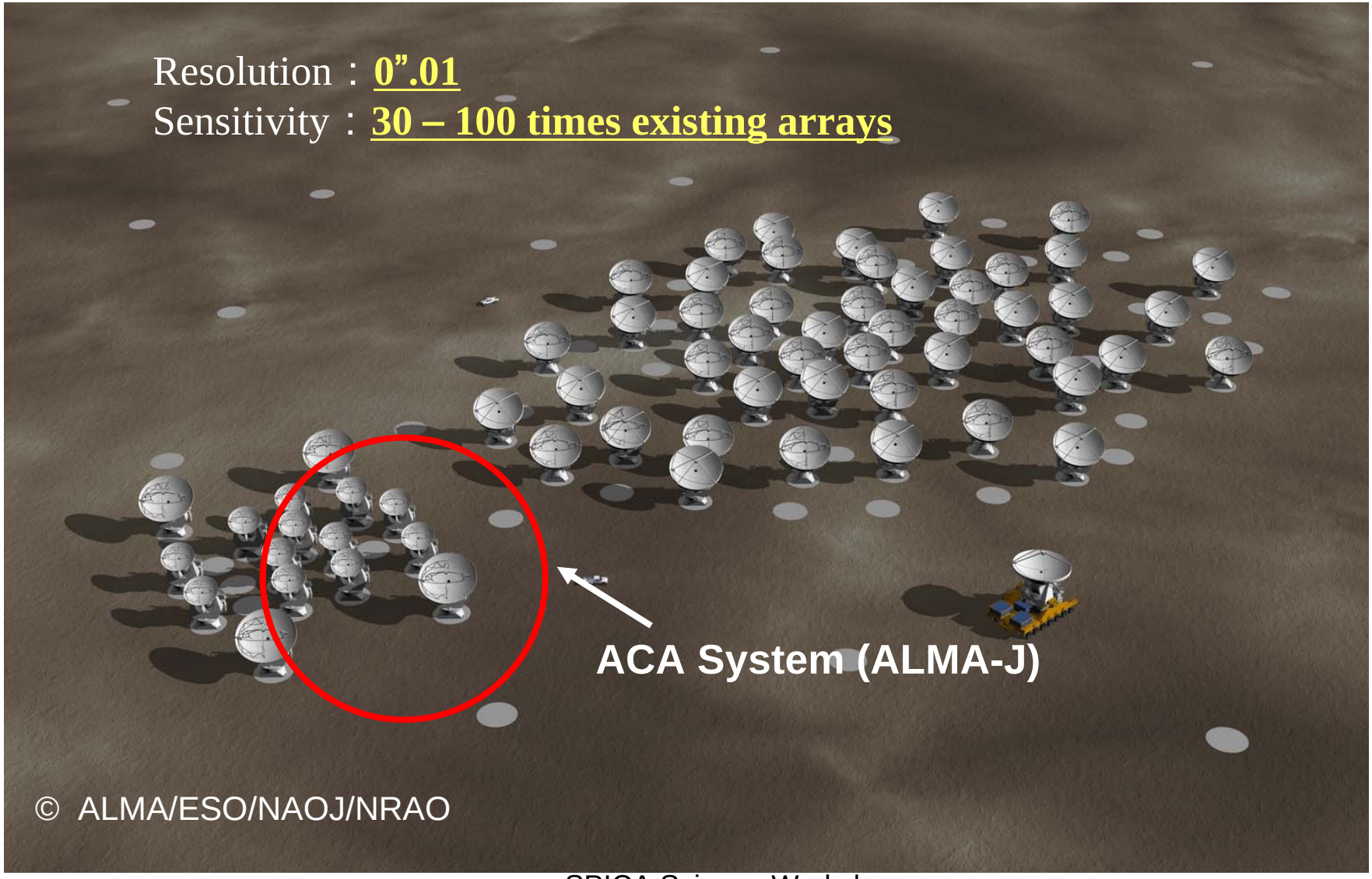
  Wavelength, Resolution, Sensitivity, Dynamic Range

Spectral Energy Distribution ~scaled to M82~

Maiolino 2008

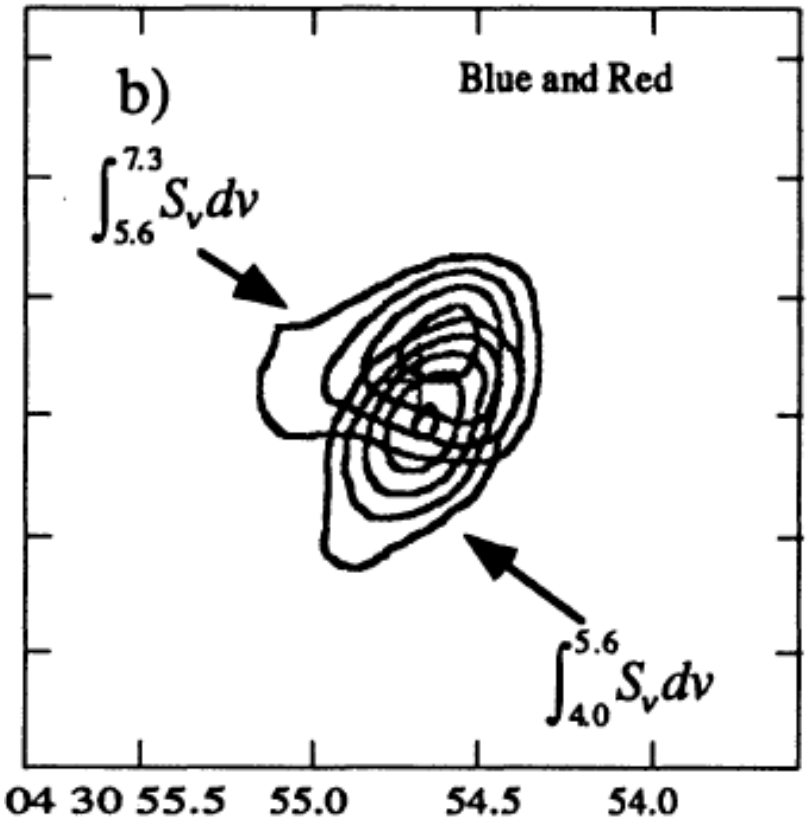


ALMA

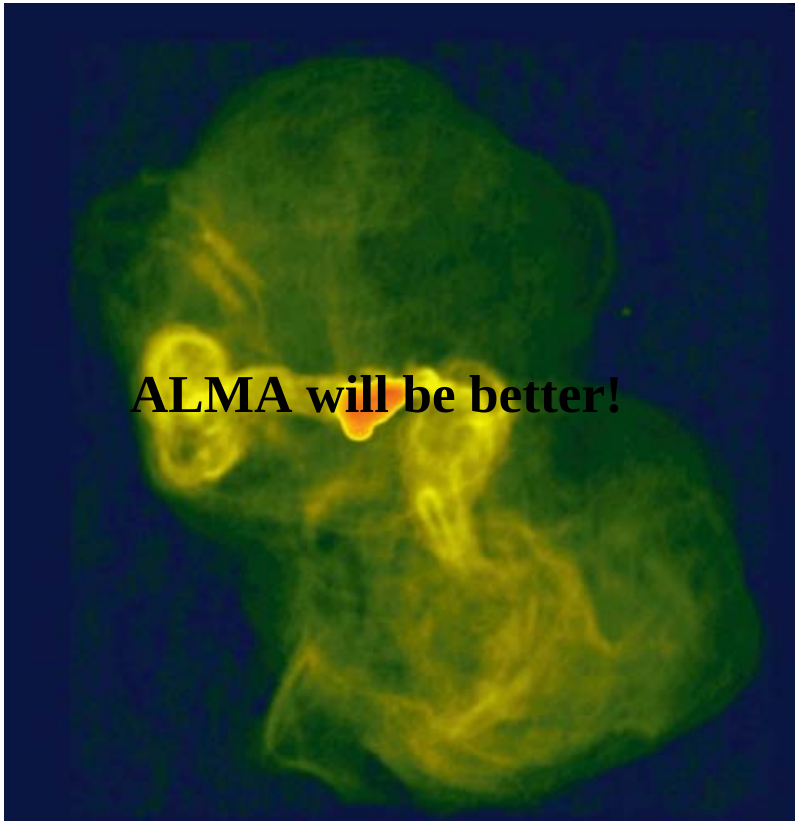

Resolution：0”.01
Sensitivity：30 – 100 times existing arrays
ACA System (ALMA-J)
© ALMA/ESO/NAOJ/NRAO

Imaging Quality

DM Tau with NMA
Saito et al. 1995



M87 with VLA
NRAO / AUI / NSF

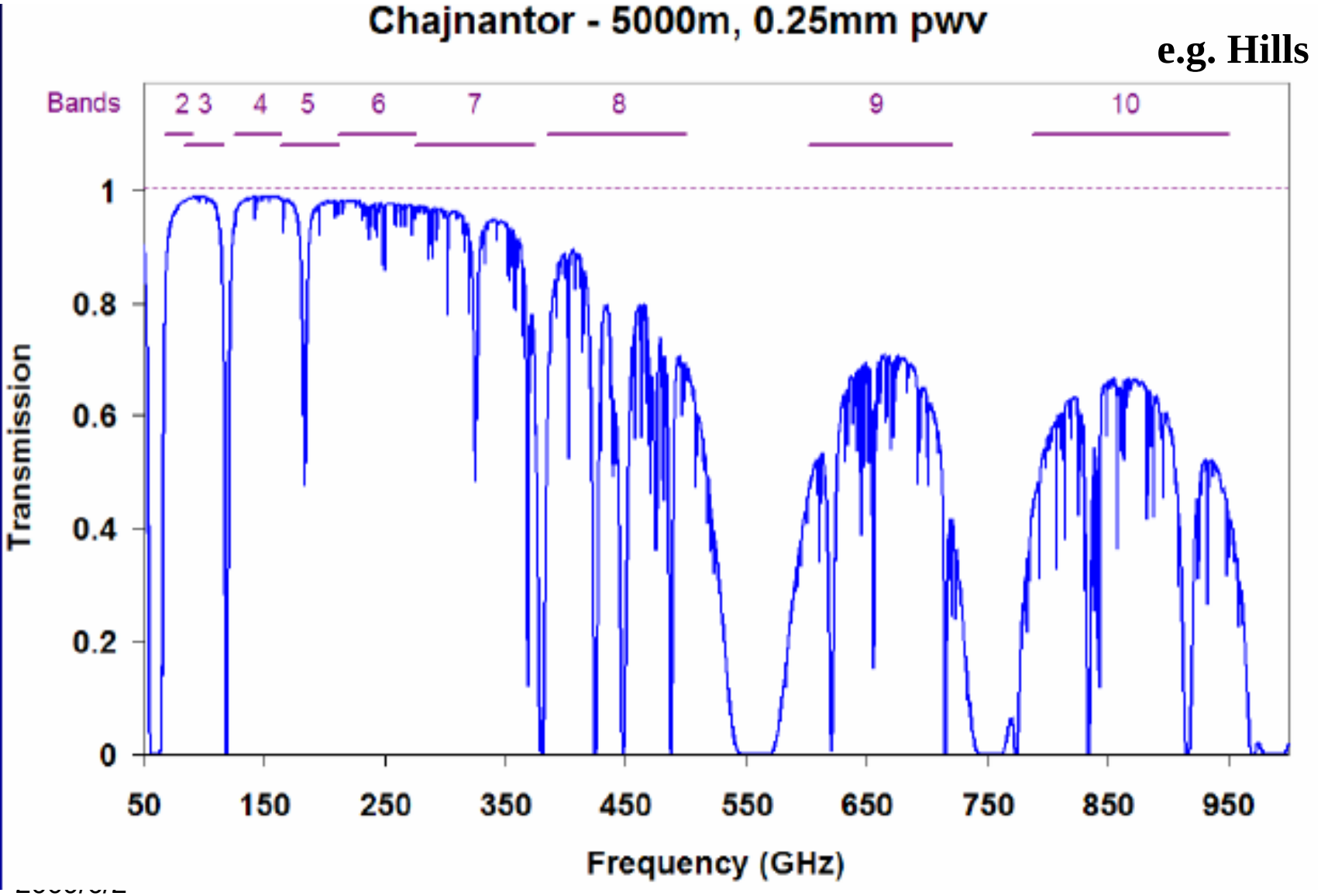


ALMA Science

- **High Resolution (down to 0”.01) / High Sensitivity**
- **Formation of Planetary Systems**
  - **Detection of large young planets**
  - **Origin of variety**
- **Galaxy Formation and Evolution**
  - **Submm galaxy (continuum, CO, CII)**
  - **Absorption lines**
- **Evolution of Interstellar Matter**
  - **Life-related Organic Chemistry**
  - **Life cycle of Dust Grains**

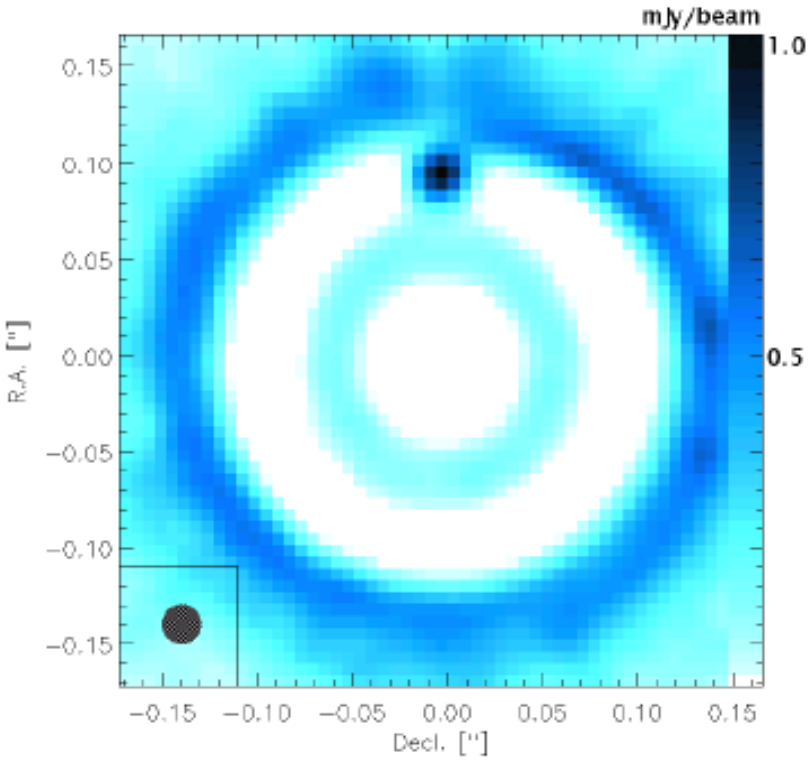
e.g. Iguchi et al. (2009), Wootten and Thompson (2009)

ALMA Wavelength Coverage



Planet Formation

Wolf & D'Angelo (2005)



D: 50pc

Mp: 5 MJupiter at 5 AU

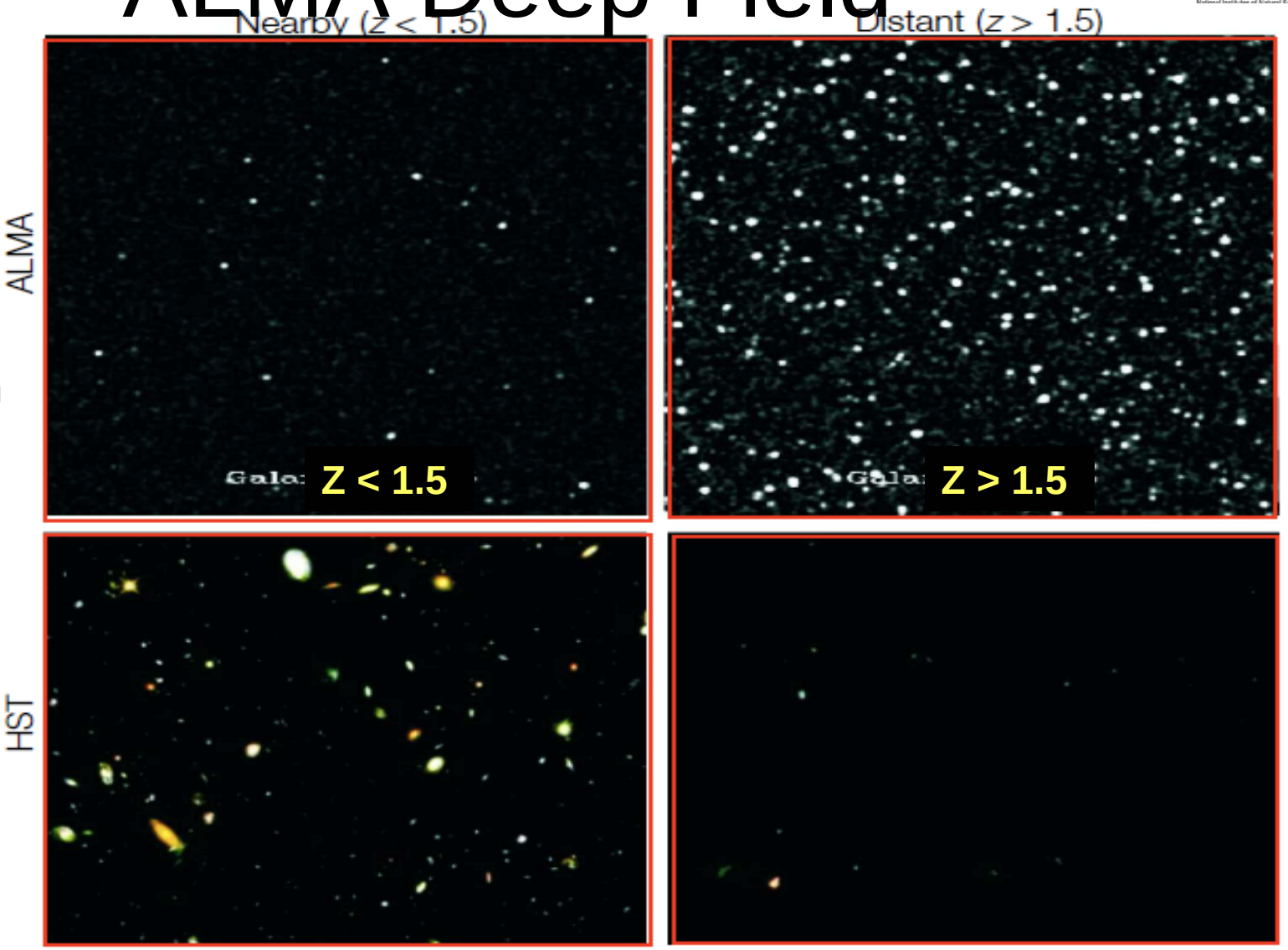
M*: 2.5 Mo

Md: 0.01 Mo

ALMA Deep Field

ALMA Simulation

HST



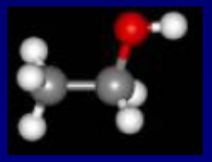
Source: Wootten and Gallimore, NRAO

Some complex organic molecules

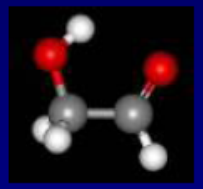
Detected

Acetic acid

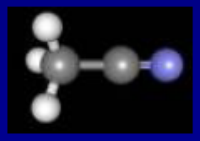
Di-methyl ether



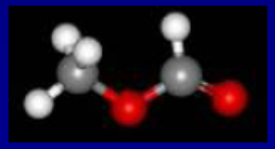
Ethanol



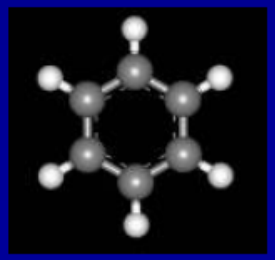
Sugar



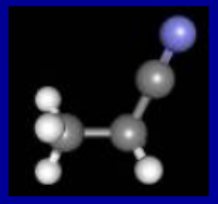
Methyl cyanide



Methyl formate

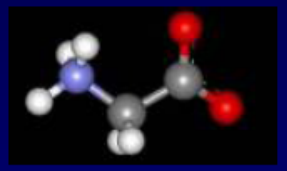


Benzene

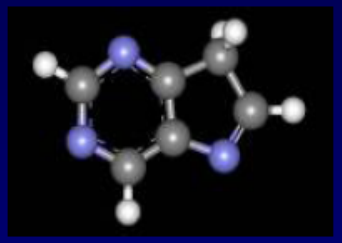


Ethyl cyanide

Not (yet) detected



Glycine



Purine

Pyrimidine

Caffeine

We do not how far this chemical complexity extends.

Taken from Hills (2009) Based on Ehrenfreund 2003

ALMA needs someone!

- ALMA's : 0.006" FWHM at 950 GHz, 14.7 km baseline over an 6" FOV

=>ALMA is not survey instruments.

- ALMA lifetime is over 30 yrs.
- Call for proposal for ALMA early science coming soon!

ALMA-SPICA Synergy 1
~ Field of View ~

- ALMA's : 6" FWHM at 950 GHz (B10)
- SPICA's : A few arcmin x a few arcmin

- SPICA's capability to survey

Recommendation: keep large FOV.

ALMA-SPICA Synergy 2
~ Wavelength Coverage ~

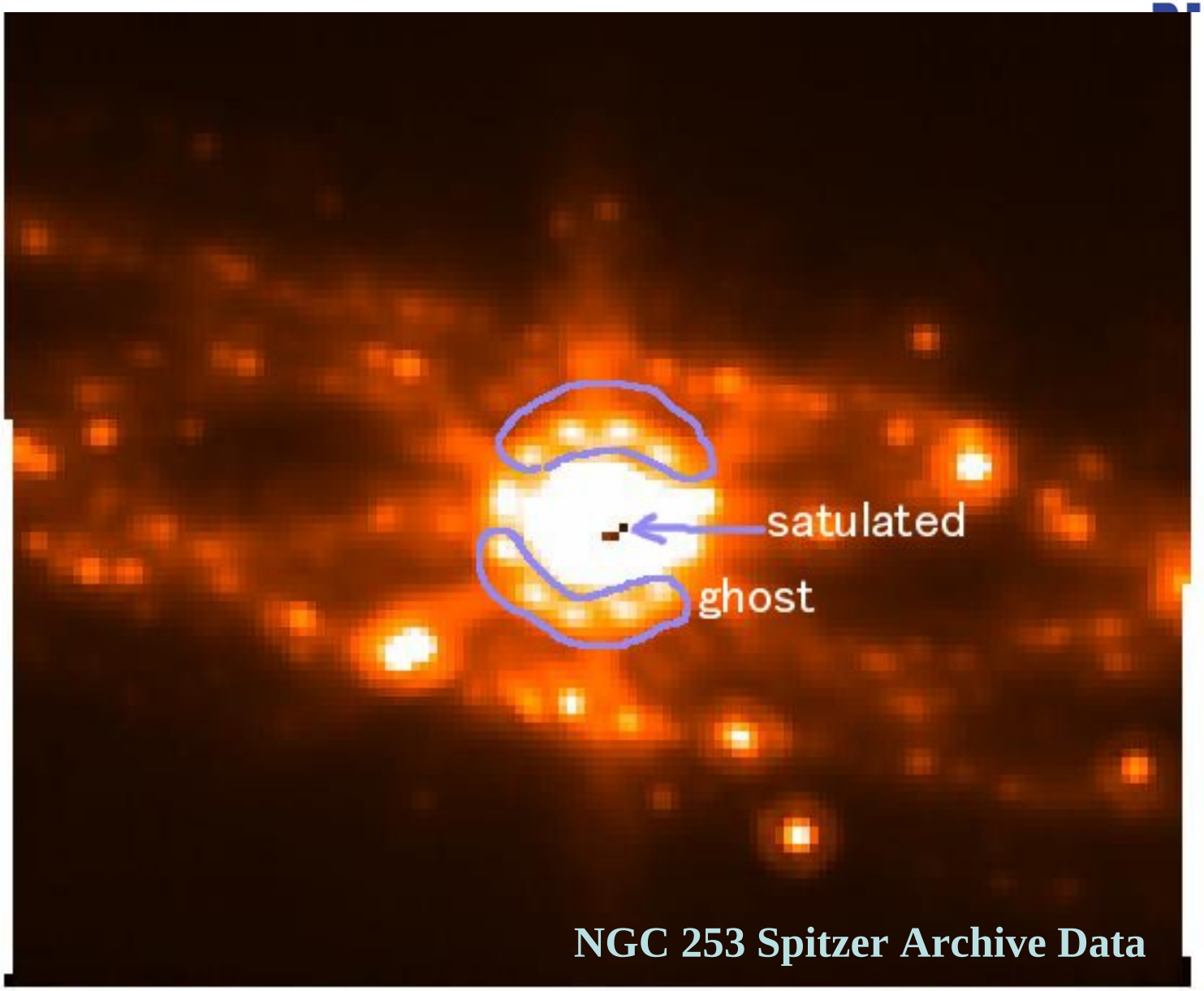
- ALMA's : 320 um – 3.6 mm (9.7 mm)
- SPICA's : 5 um – 200 um

- ALMA and SPICA is complementary.
- CII ⇒ CI ⇒ CO
- Recommendation: cover FIR range including CII spectroscopic capability

ALMA-SPICA Synergy 3
~ Dynamic Range ~

- ALMA's : 1:50000 (image dynamic range)
- SPICA's : ??

- High sensitivity is not sufficient.
- Recommendation: keep high dynamic range in imaging.


satulated
ghost
NGC 253 Spitzer Archive Data
40
60
80
100
120
140
160
180
200

ALMA Operation

ALMA : Scientists Friendly Instrument

- Service observation with flexible (dynamic) scheduling.
- Default output to the astronomer are reliable images.
- ALMA Responsible for the data product quality.
- User Support by ALMA Regional Center (EA: Mitaka)
- Usable for non-astronomers

ALMA Regional Center (ARC)

- East Asia, Europe, and North America
- User Support
  - Web pages
  - Helpdesk
  - F2f support
  - Data delivery
  - Archive
- East Asia ARC (at Mitaka, NAOJ)

Someone says;

Even Biochemists can use ALMA Data!

SPICA User Support

- Kind Helpdesk
- Easy for non-experts
- Friendly Archive System

These are keys to create chemistry between SPICA and ALMA.

Exploration of the unknown

- Lessons from History
  - Majority of discoveries were not from theory.
  - What a Radio telescope built for is almost never what it is known for

    e.g. VLA case
    - A quarter of its time during its initial decase of operation on the key science drivers listed in the funding proposal.

Astronomical discoveries are usually made by people who are curious and take the time to understand their instrument, with less emphasis on a quick publication.

By Wilkinson et al. 2004

Summary

- ALMA and SPICA are producing stunning results, separately, but can potentially produce more jointly.
- Synergy is not easy, but … more communication is needed between the two.
- Keep large FOV, FIR wavelength coverage, and high dynamic range.

www.alma.info

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