



# Astronomy: Trilateral Partnership on ALMA

(Atacama Large Millimeter/submillimeter Array)

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# ALMA Partnership

## Partnership

- Europe - Japan - North America

## Construction & Operations

- European Southern Observatory (ESO)
- National Radio Astronomy Observatory (NRAO - NSF, AUI (Associated Universities Incorporated) and NRC National Research Council of Canada)
- National Astronomical Observatory of Japan (NAOJ - NINS, and Academia Sinica/Taiwan)

→ Joint ALMA Observatory (JAO)  
Cerro Chajantor, Chile

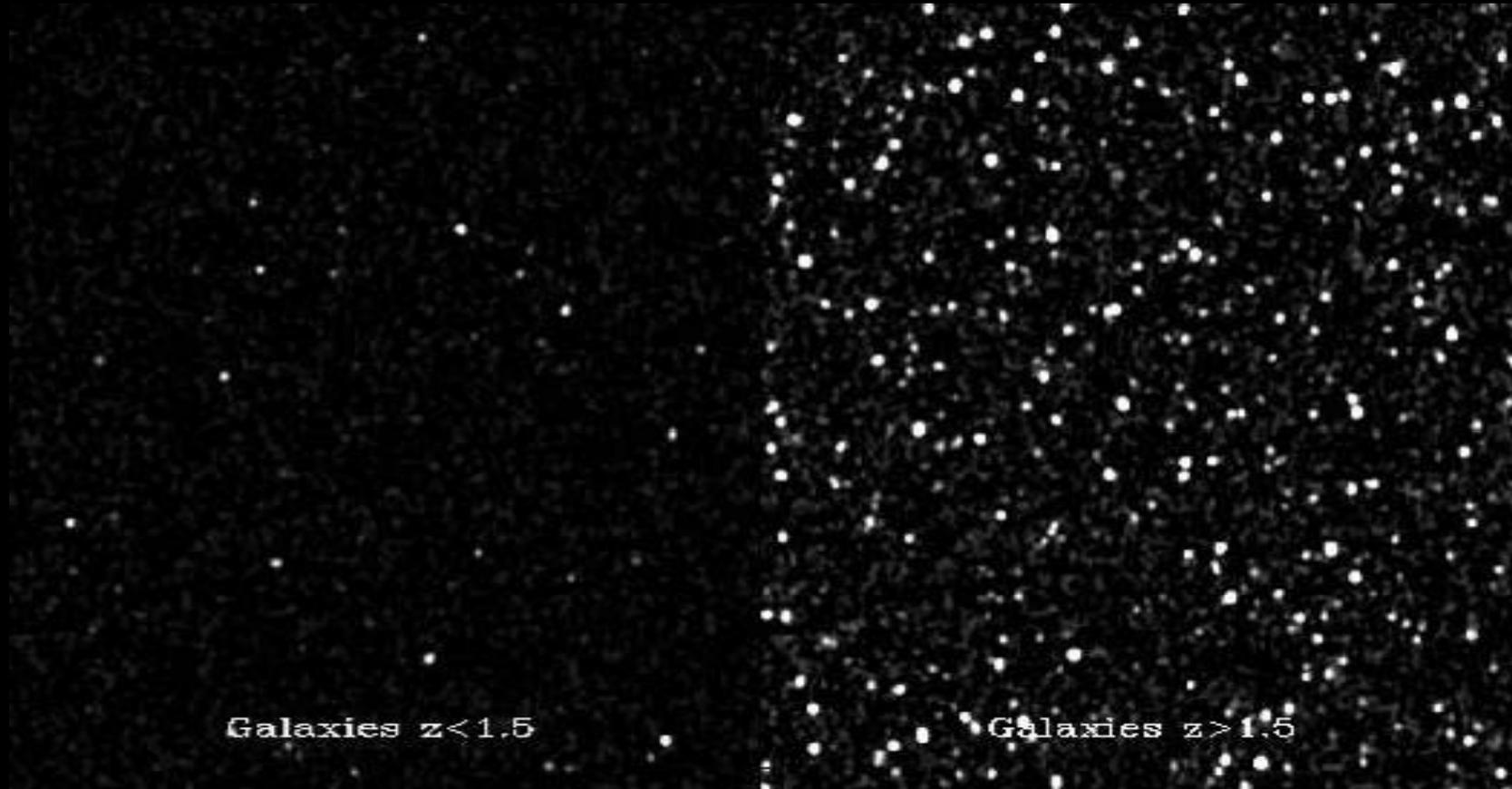


# ALMA

## Merges Long-term Common Goals of Partners:

- High fidelity, high resolution, imaging
  - High spectral line sensitivity
  - System Flexibility (hardware/software)
- Currently:
    - Site construction underway, hardware & software in production;
    - Eight antennas on site
    - Early science begins 2011

# ALMA DF: Rich in Distant Galaxies

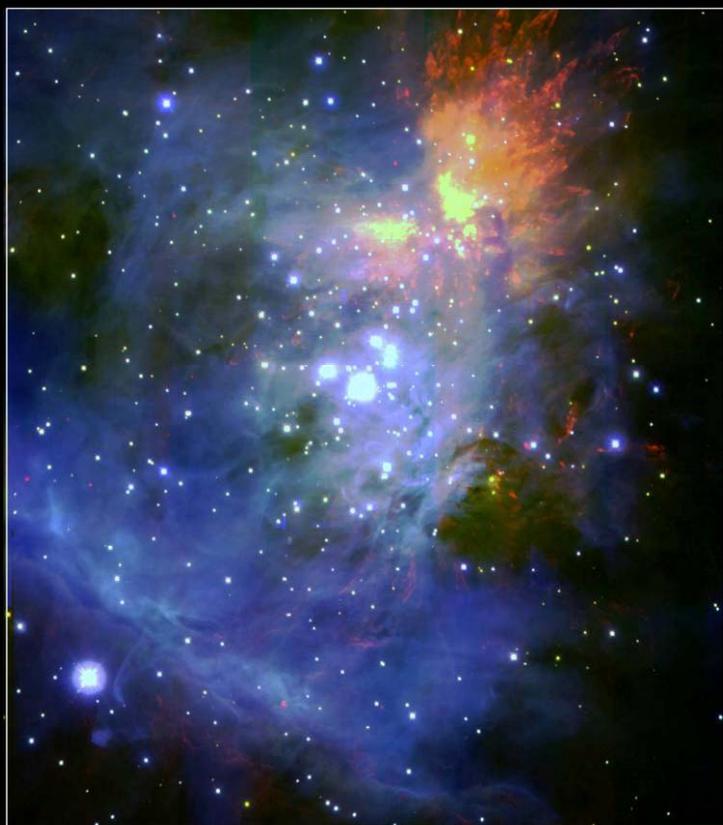


Nearby galaxies in ALMA DF    Distant galaxies in ALMA DF



# ALMA Key Science : Astrochemistry

Spectrum courtesy B. Turner (NRAO)

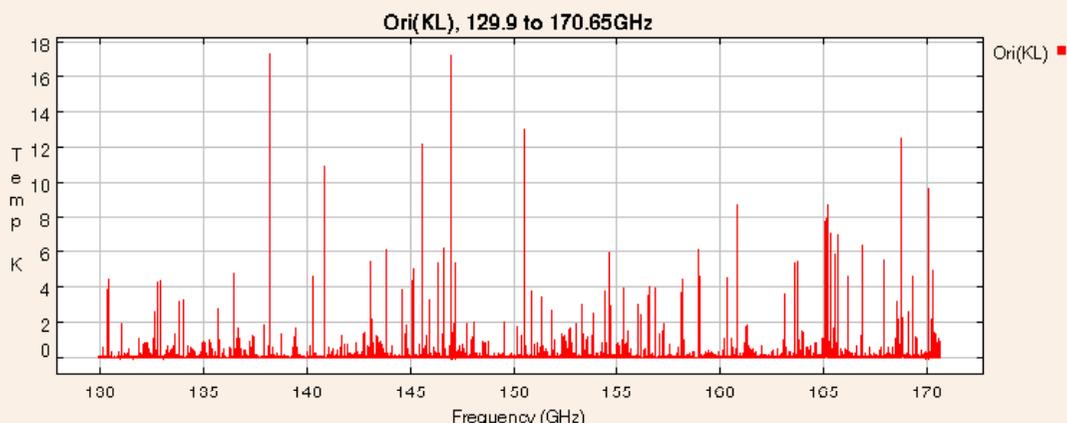


Orion Nebula

Subaru Telescope, National Astronomical Observatory of Japan

CISCO (J, K' & H<sub>2</sub> (v=1-0 S(1)))

January 28, 1999



- Millimeter/submillimeter spectral lines strong in planets, young stars, many distant galaxies.
- Most observed transitions of known interstellar molecules in mm/submm ~17,000 lines in small 2mm region (above)

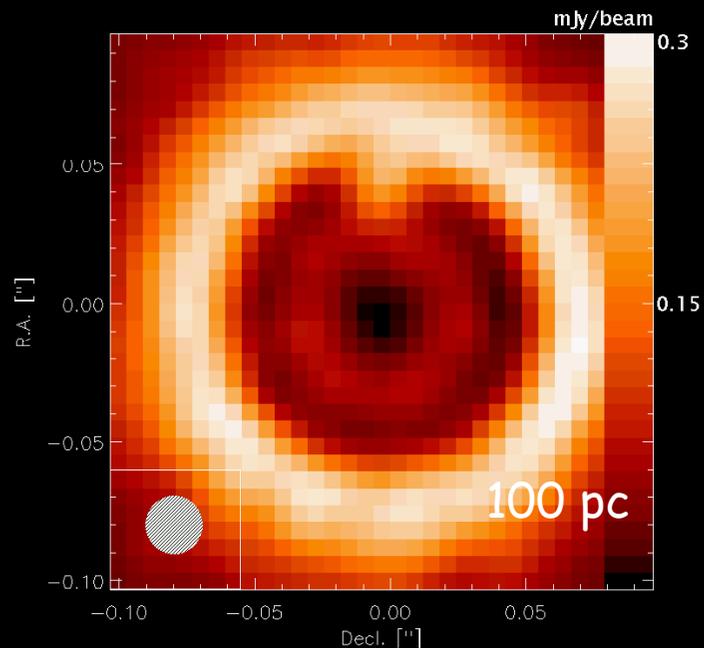
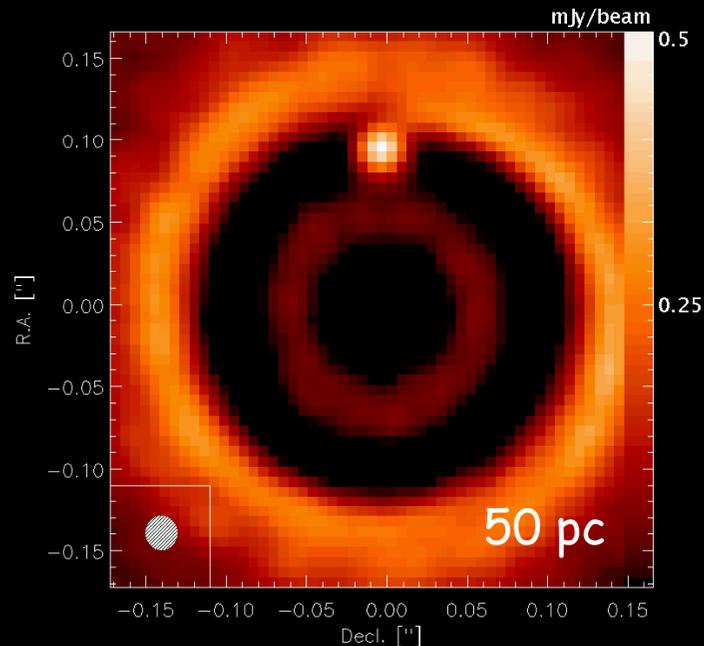
# ALMA Key Science Planetary regions, nearby disks

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

Orbital radius: 5 AU

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

ALMA: 10km,  $t_{\text{int}}=8\text{h}$





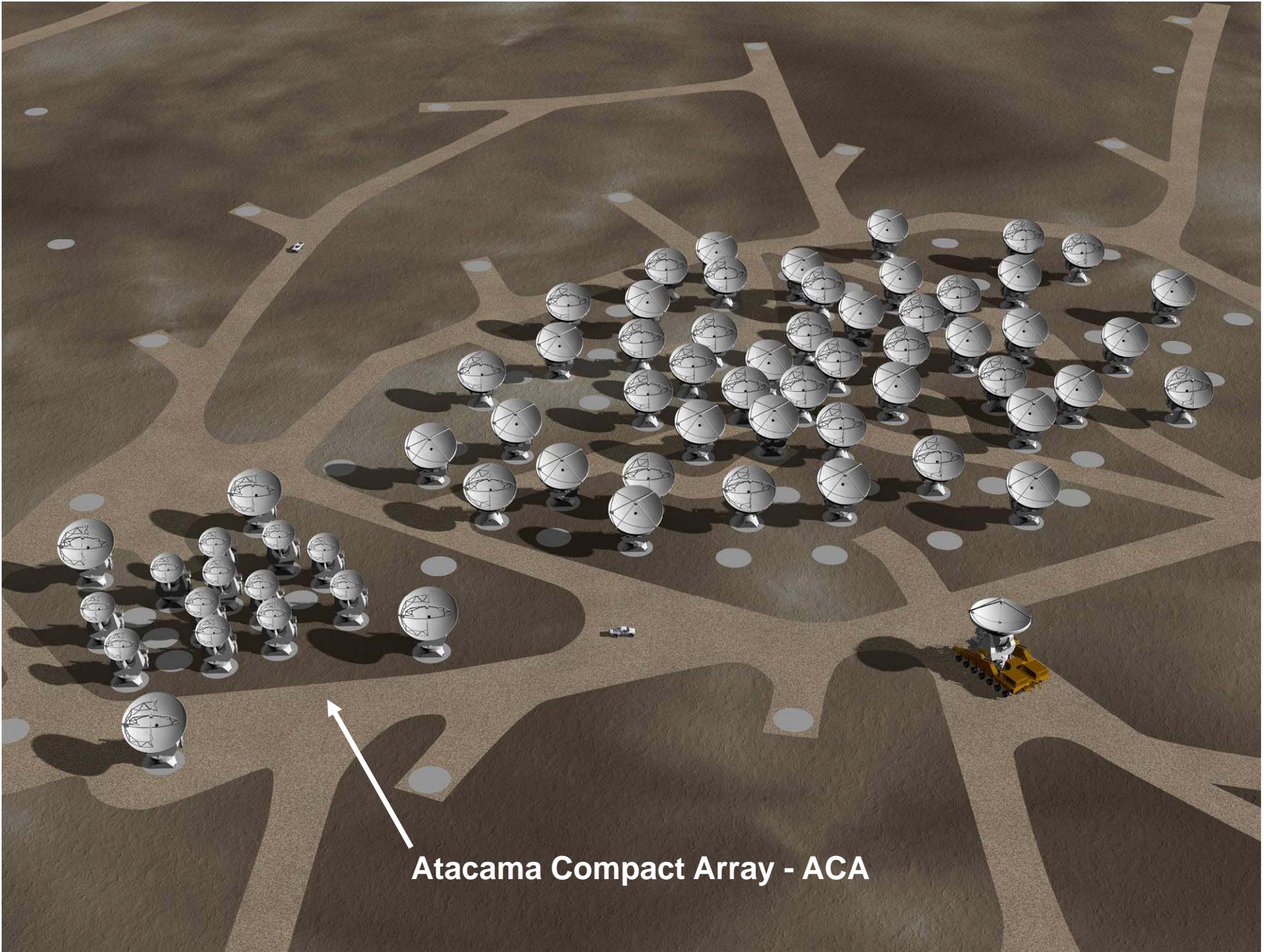
# Technical Specifications

- 50 x 12-m antennas & 12 x 7-m + 4 x 12-m antennas
- Surface accuracy  $\pm 25 \mu\text{m}$ , 0.6" reference pointing in 9m/s wind, 2" absolute pointing all-sky.
- Array configurations between 150 m to ~15-18 km.
- 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.
- Angular resolution 0.02" at 1mm with 10 km baseline

# Array Operations Site



Chajnantor: 5000m elevation



**Atacama Compact Array - ACA**

MELCO #1-3 : Oct 2007



17.10.2007 17:03

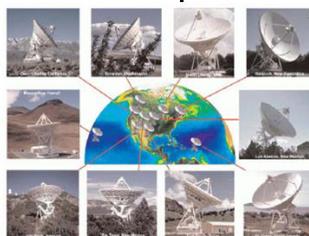
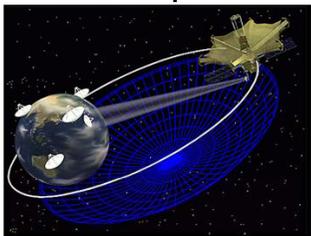




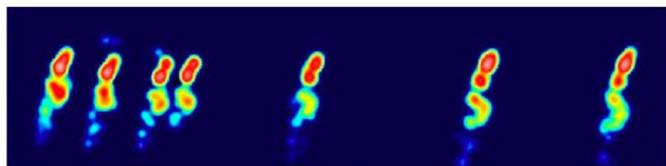
# Builds and expands on other NSF-Japan partnerships

## Subaru-Gemini Time Exchange 2009 Kyoto Symposium

### NSF Cooperation in VSOP Space VLBI



- NSF operated key ground telescopes in Japanese-led VSOP space-ground interferometry mission
- Key data- and clock-link station at NSF Green Bank site
- Below: 4 yr of VSOP+VLBA images of quasar 1928+738



Murphy et al. 2003



### Radio Spectrum management



## ...and Sloan Digital Sky Survey collaboration



# Looking to future

## Thirty Meter Telescope (TMT)

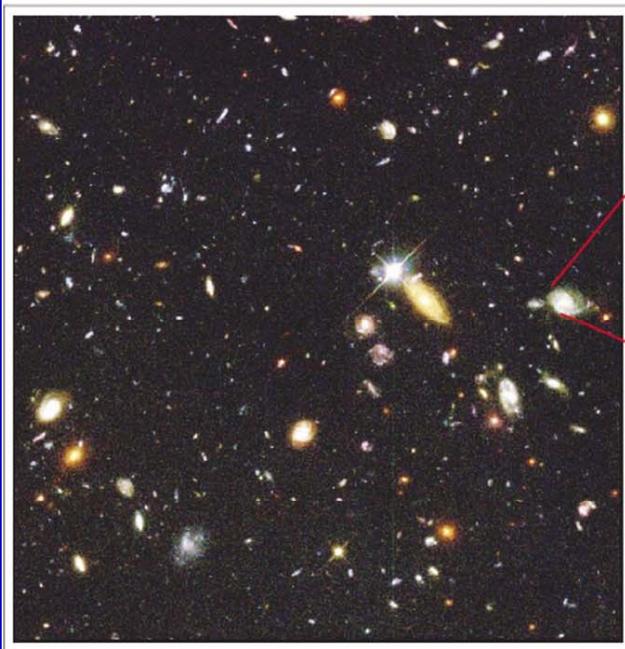


- 30-meter diameter primary mirror
- 492 segments
- Adaptive optics (AO) an integral part of the original design
  - Erases blurring effect of earth's atmosphere
- International partnership
- Highly ranked in recent US "decadal" astronomy survey
- NSF participation sought

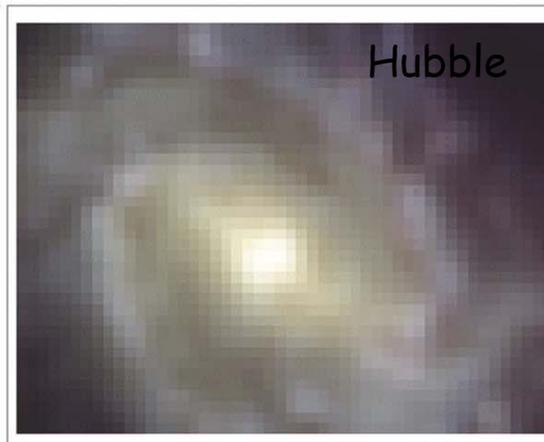


# Distant Galaxies with Adaptive Optics

Hubble Deep Field



HST resolution



*Credit: M. Bolte UCO*

30m + adaptive optics resolution