ALMA: Imaging the cold Universe

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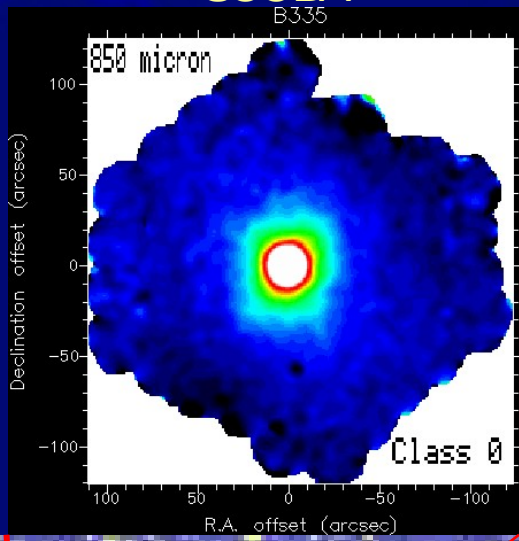
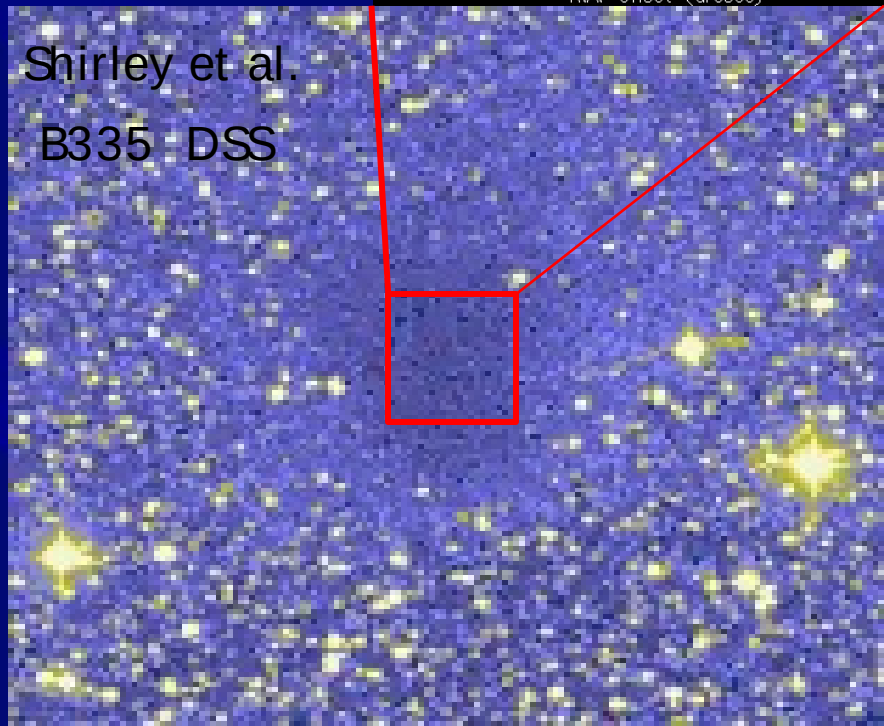
National Research Council Canada

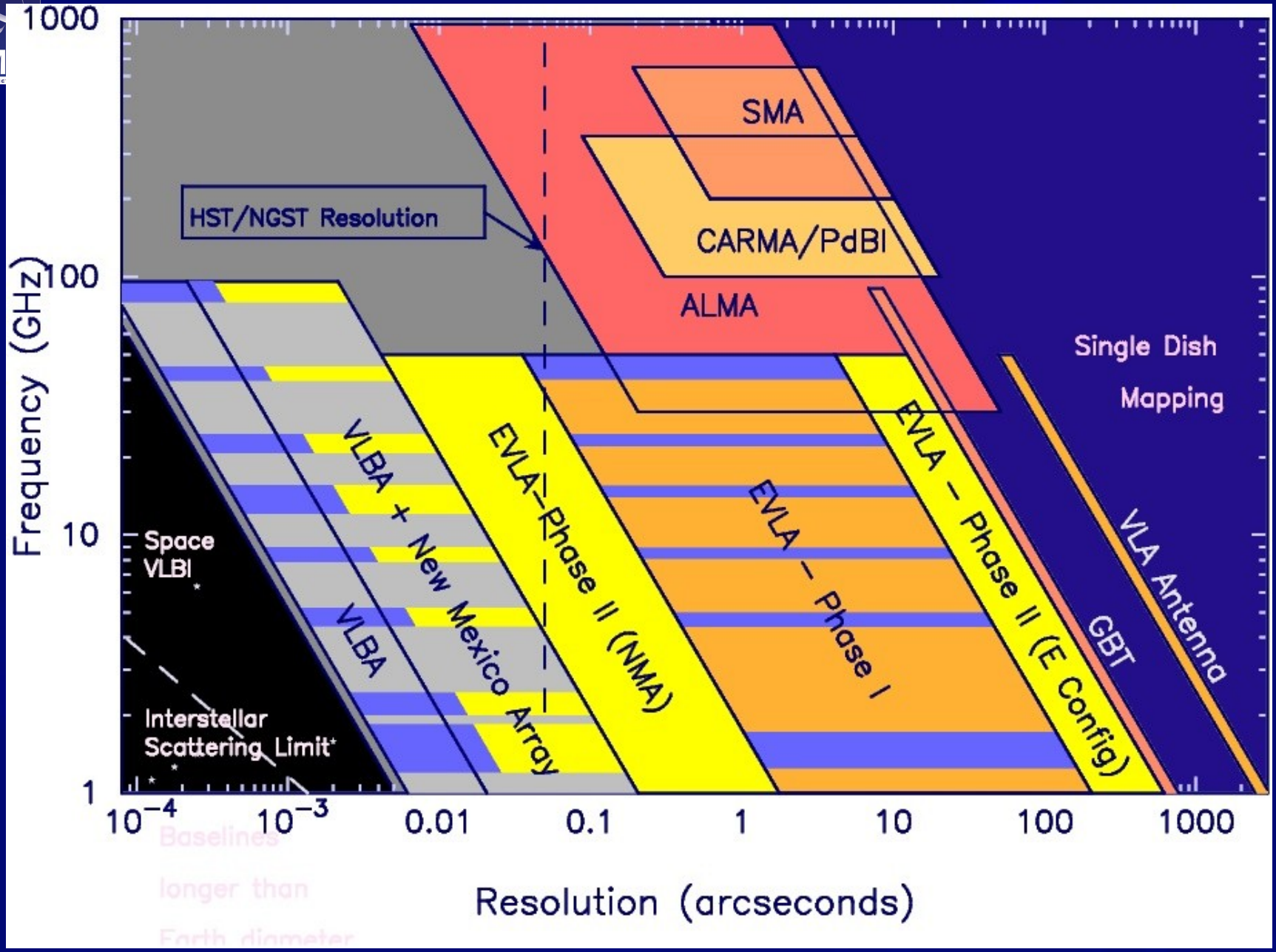
(sub)mm astronomy: unveiling the cold, obscured universe

SCUBA





Giant Steps I: Frequency and resolution



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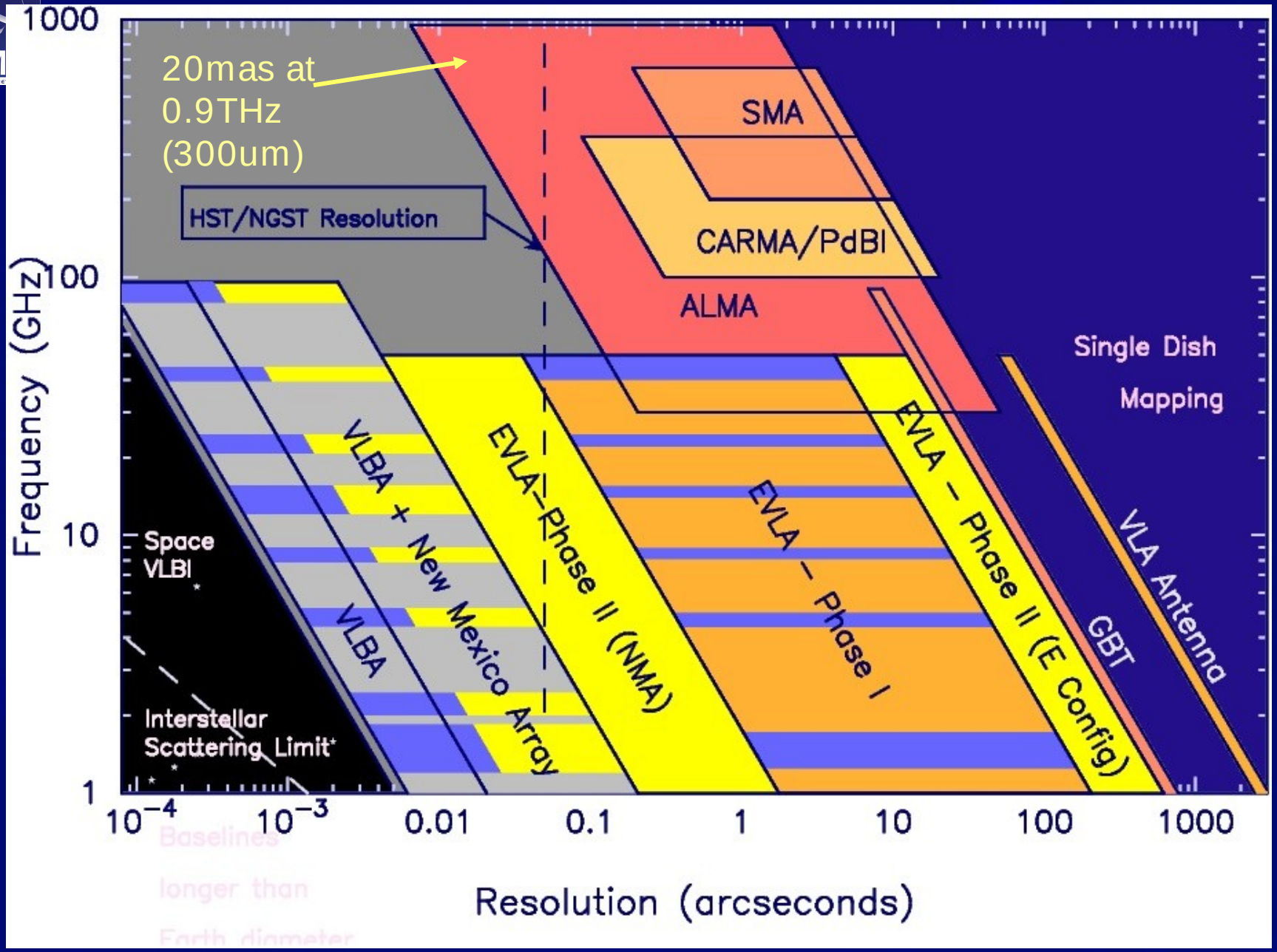
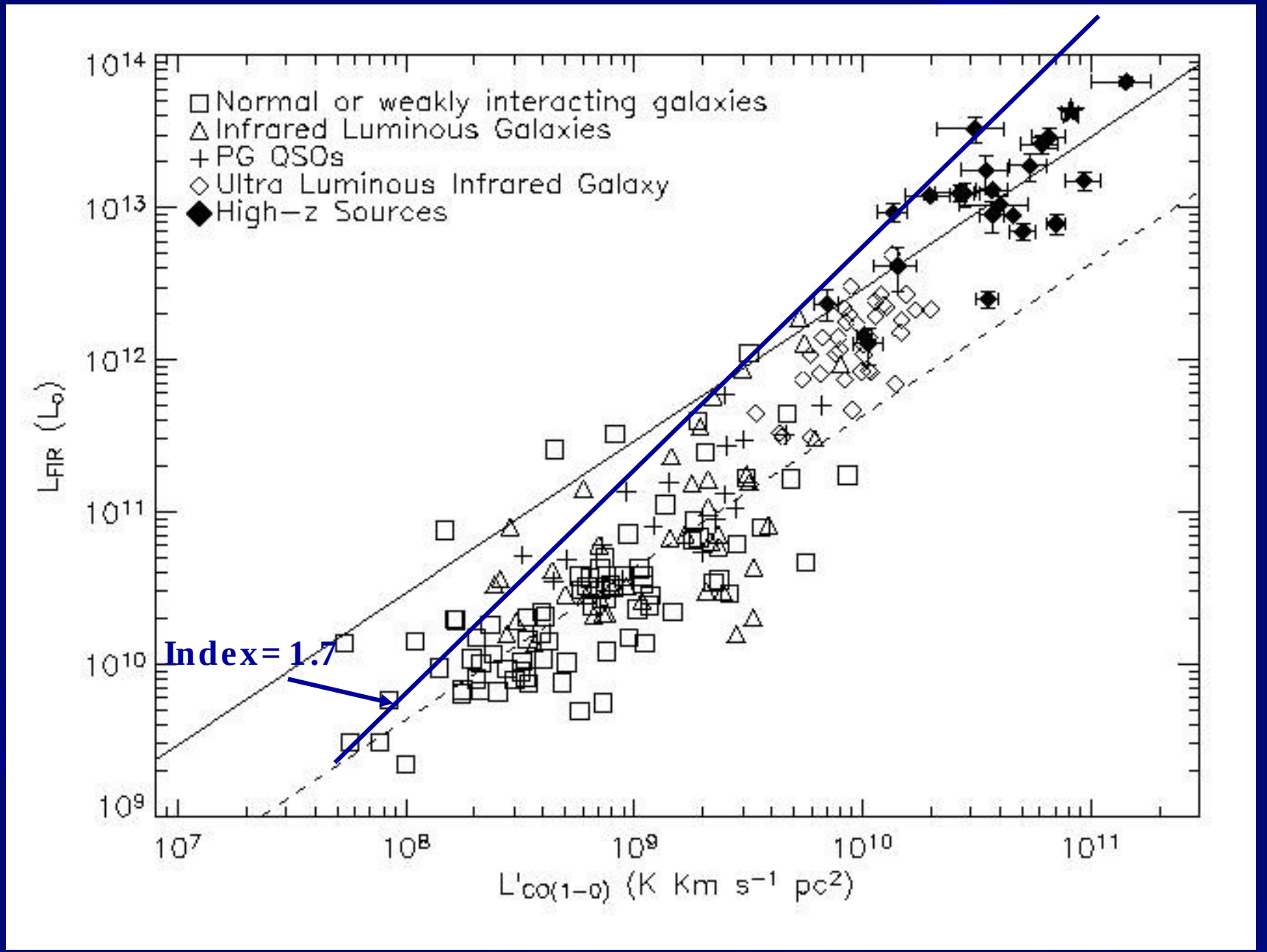
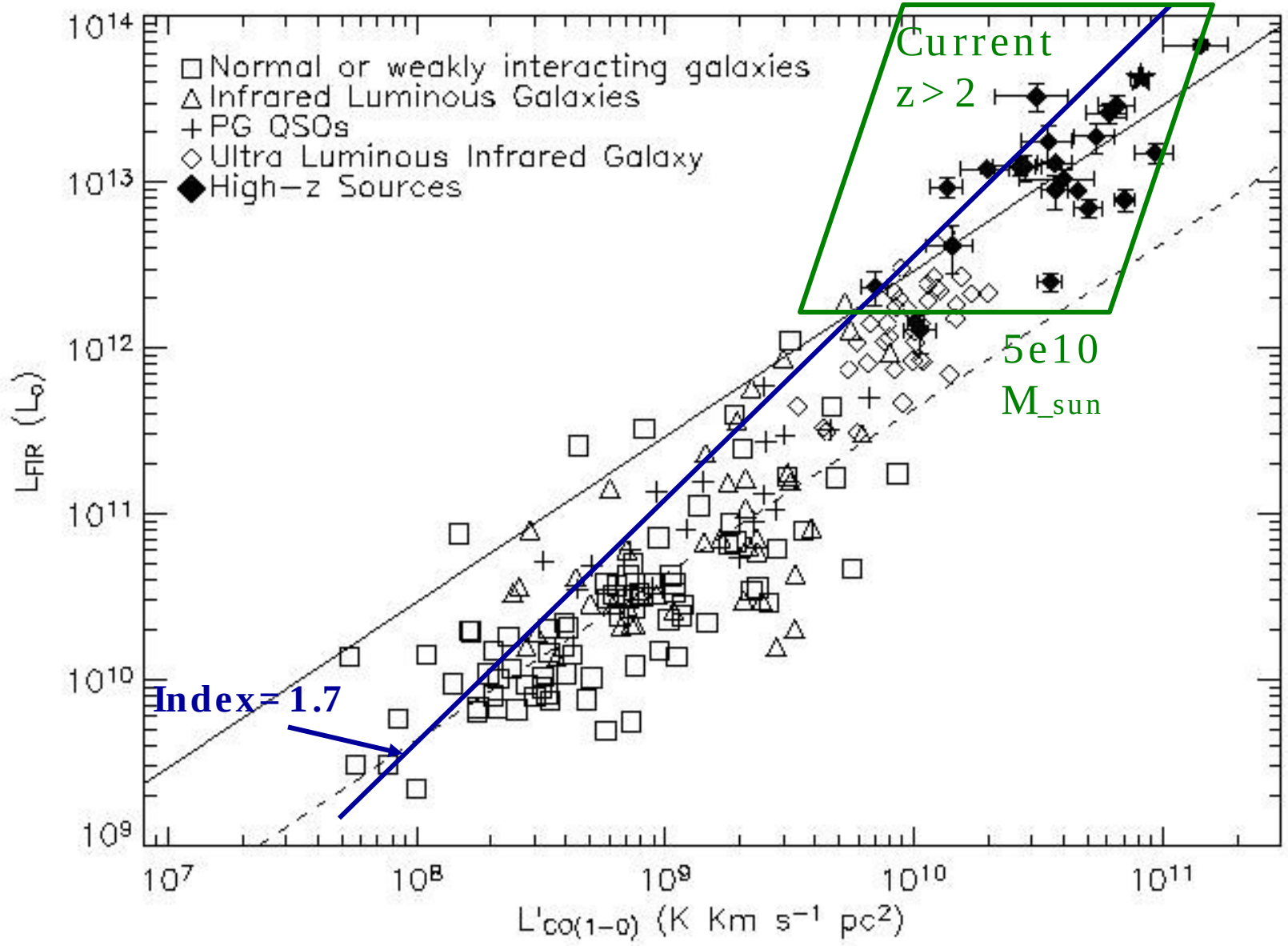


Giant Steps II: Sensitivity



Giant Steps II: Sensitivity



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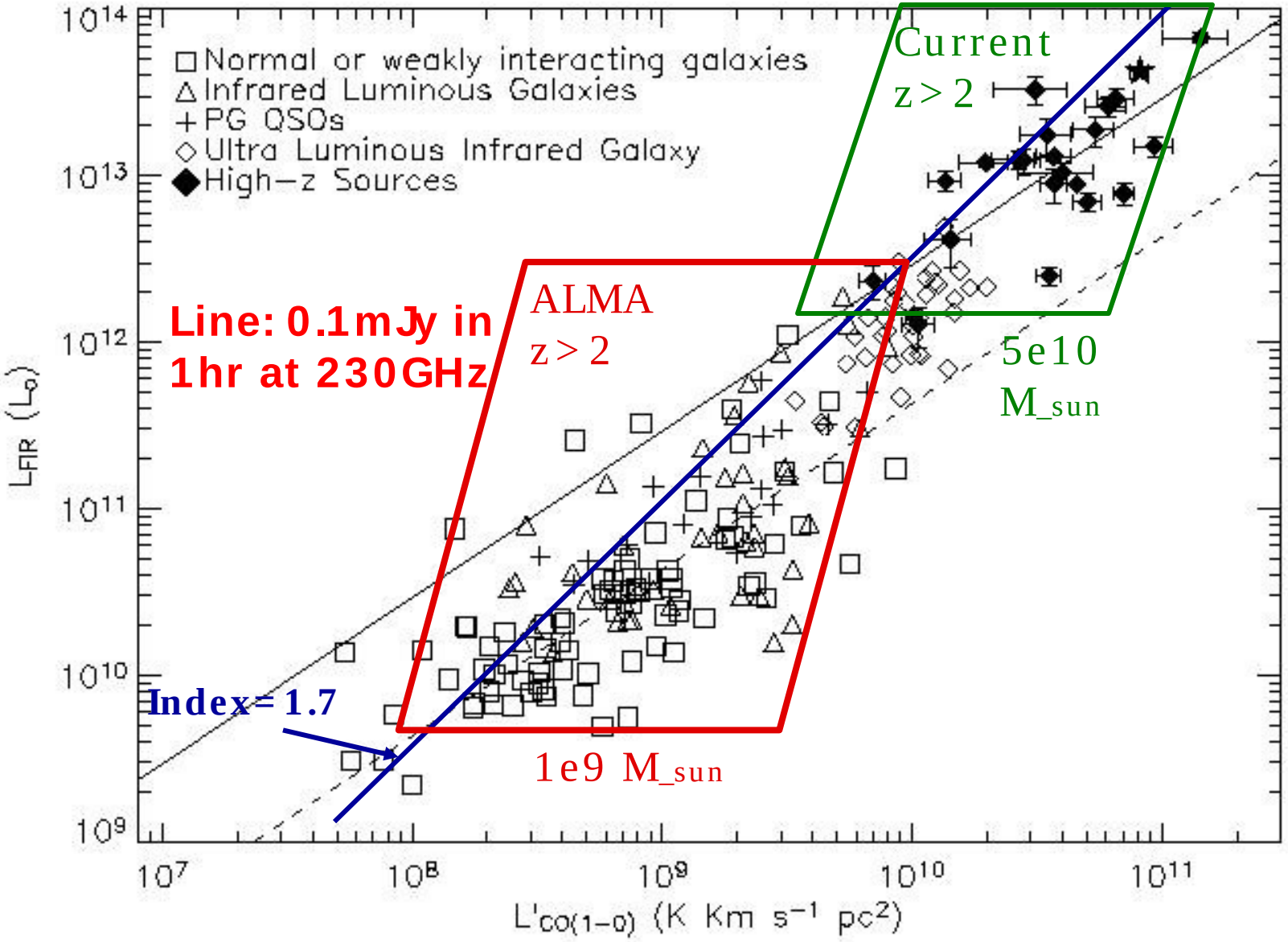
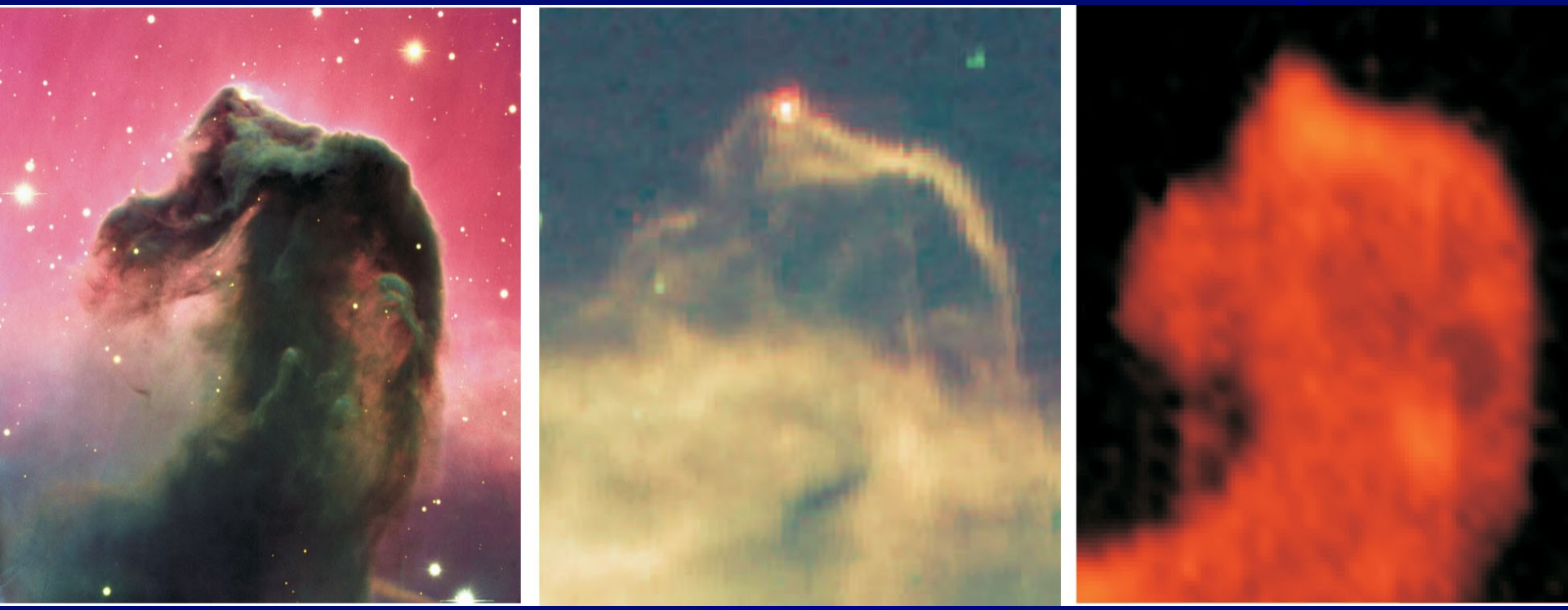


Giant Steps III: Image quality – 50+ ant, ACA, TP

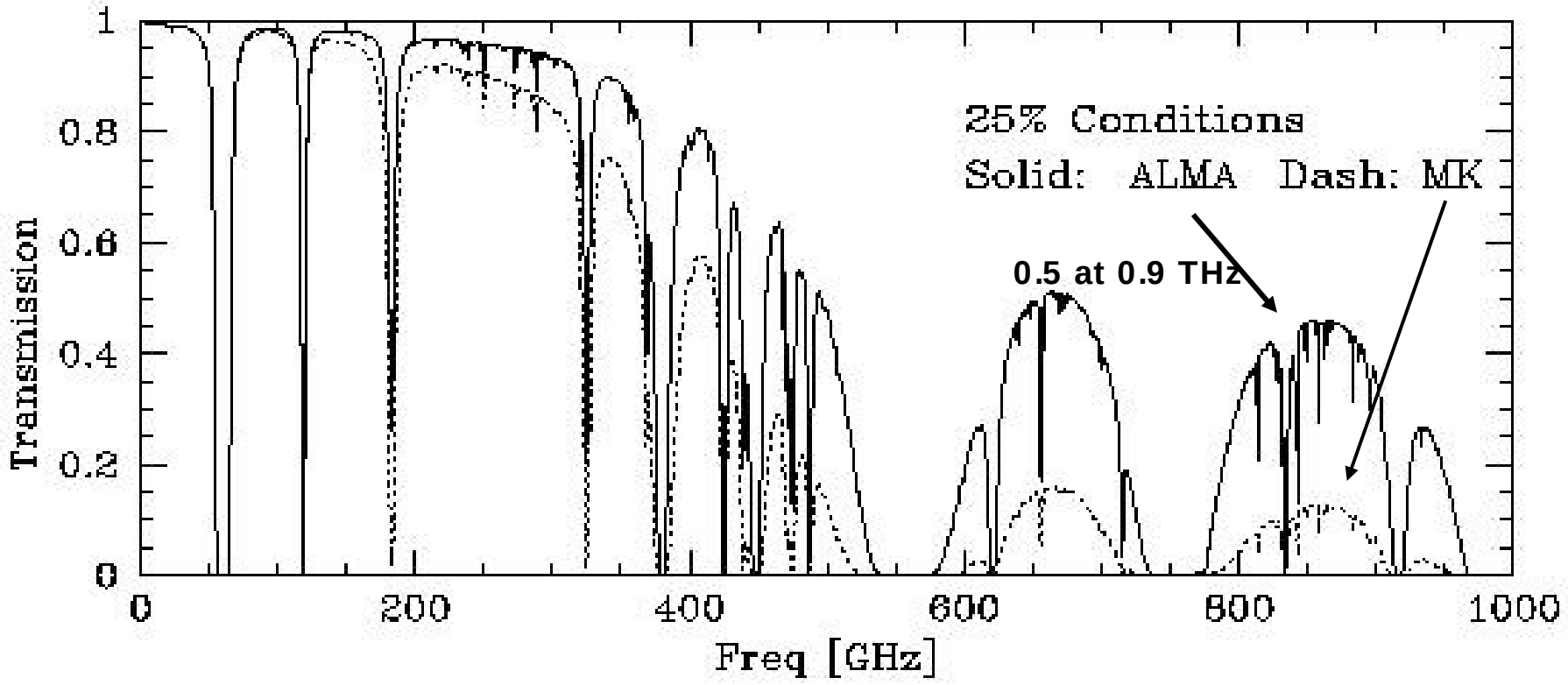
Optical/ ESO **IR/ ISO** **CO 3-2/ CSO**



T_line = sub-K at 0.25 arcsec res.

T_cont = mK at 0.25 arcsec res.

Giant Steps IV: Site quality

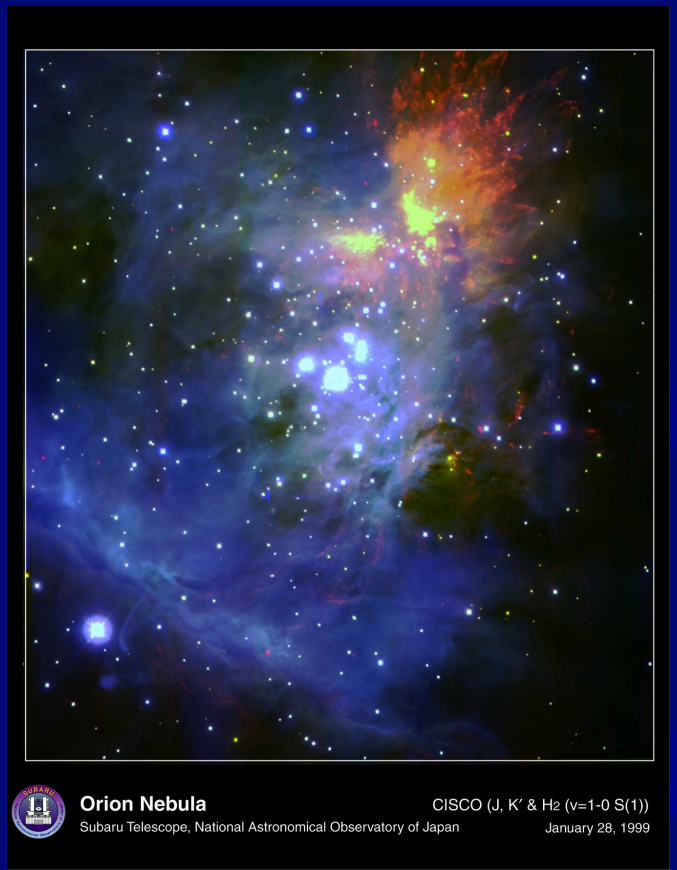


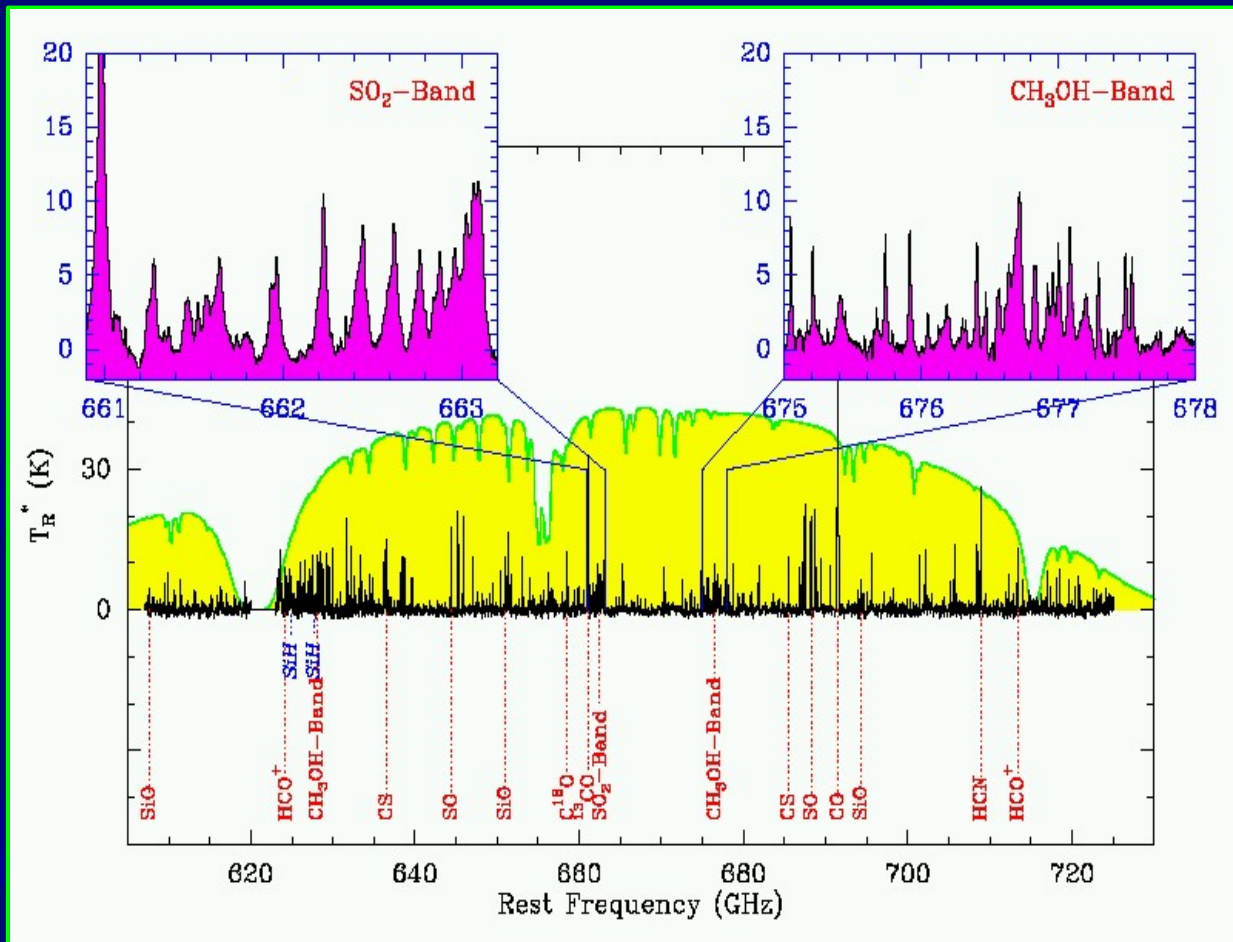
Birth of stars: physics/chemistry of star formation in 3D

Line confusion limited => new mode of operation: targeted line studies

Select lines as probes of: density, temperature, excitation, evolutionary state, or dynamics

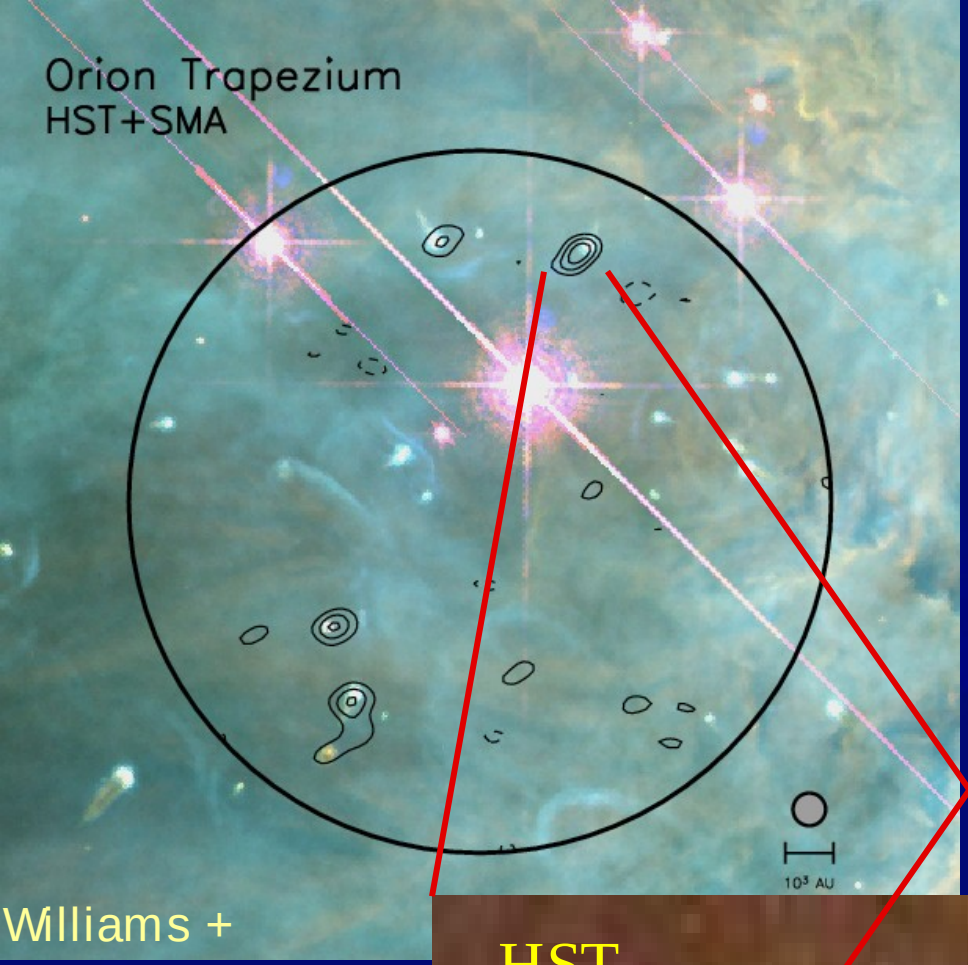
Puts pressure on laboratory astrophysics, and data analysis/visualization S/W

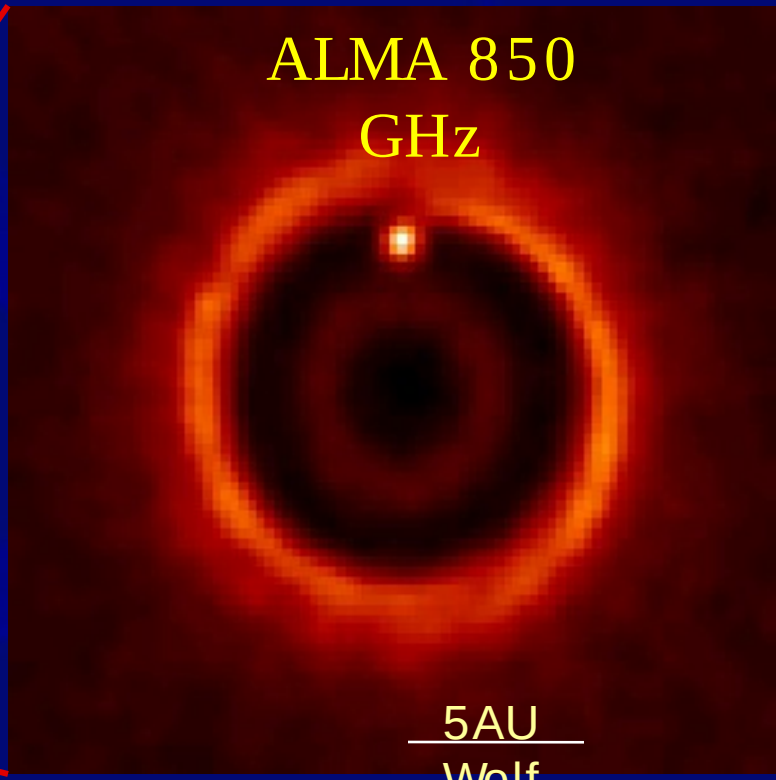




Birth of planets

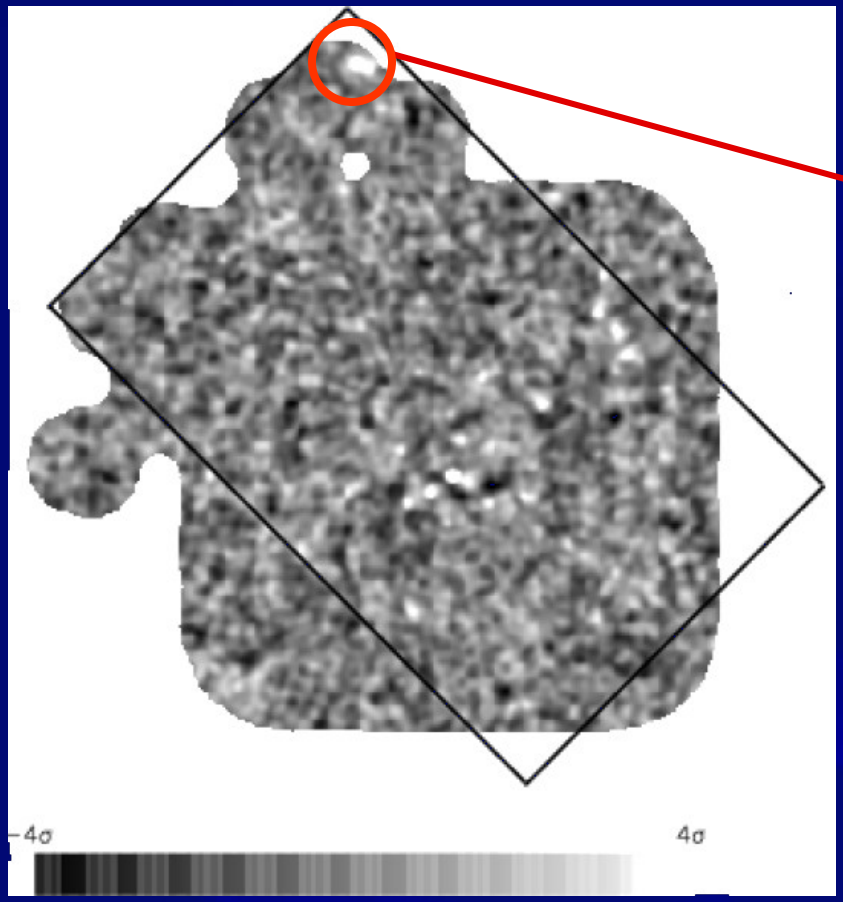
- M_{planet} / M_{star} = 1.0 M_{Jup} / .5 M_{sun}
- Orbital radius: 5AU at 50pc distance
- Disk mass = circumstellar disk around the Butterfly Star in Taurus



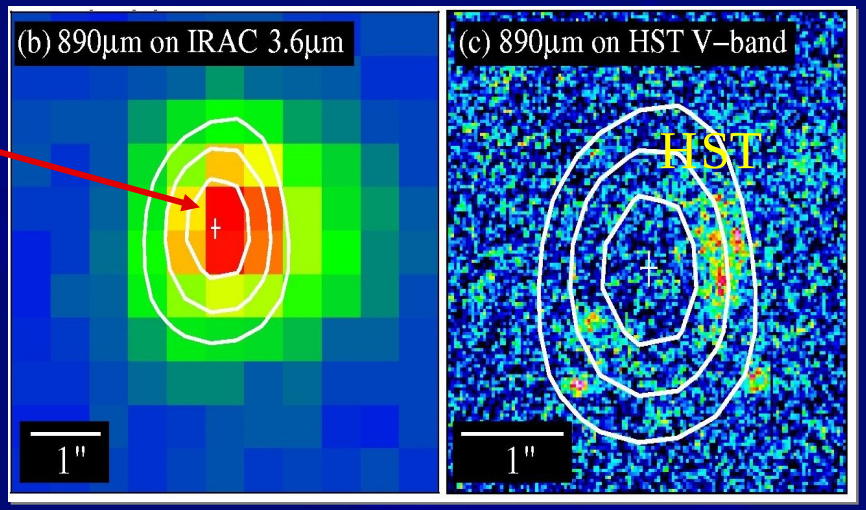


Submm surveys: Probing the epoch of "galaxy formation" (z = 1.5 – 3)

SCUBA
20mJy



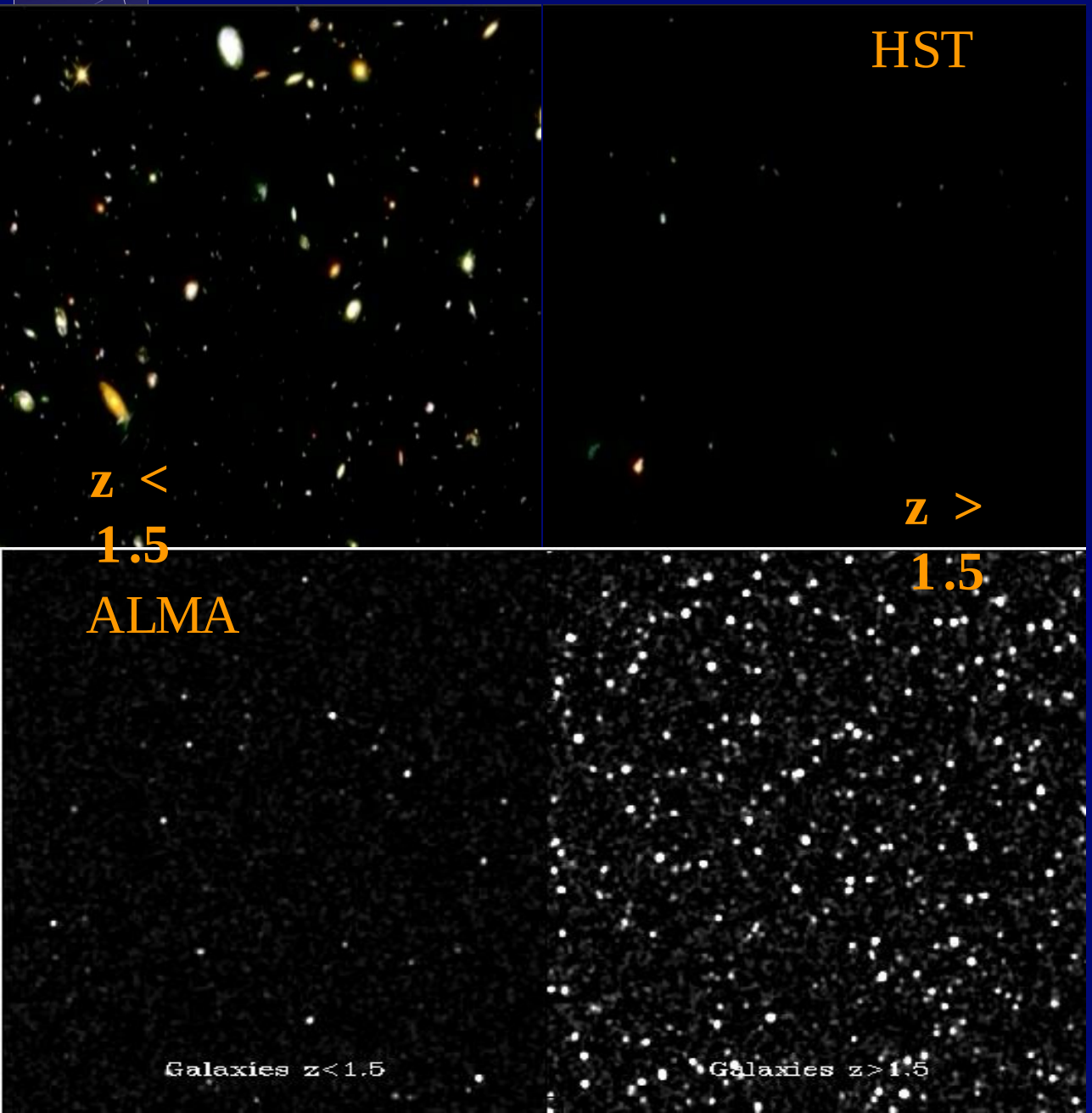
SMA/ Spitzer



20mJy at 350 GHz

Comparable SFR at z > 2 in dusty starbursts ("submm gal") as optically selected galaxies = formation of large elliptical galaxies?

ALMA Deep field: 'normal' galaxies at high z



Detect current submm gal in seconds!

ALMA deep survey: 3days, **0.1 mJy (5σ),** 4'

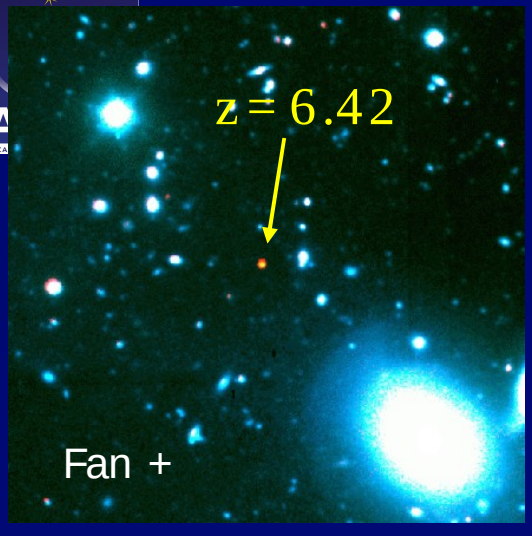
HST: few 1000 Gal, most at z<1.5

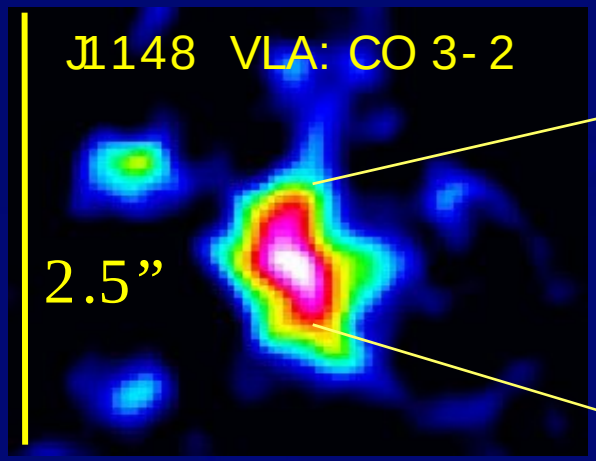
ALMA: few 100 Gal, most at z>1.5

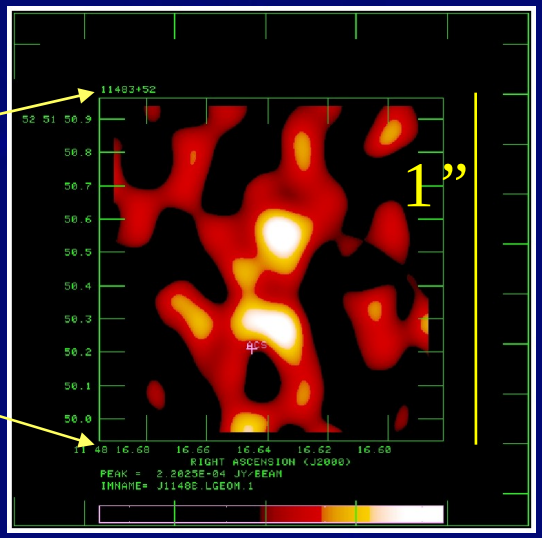
Parallel spectroscopic surveys, 100 and 200 GHz: CO/other lines in majority of sources

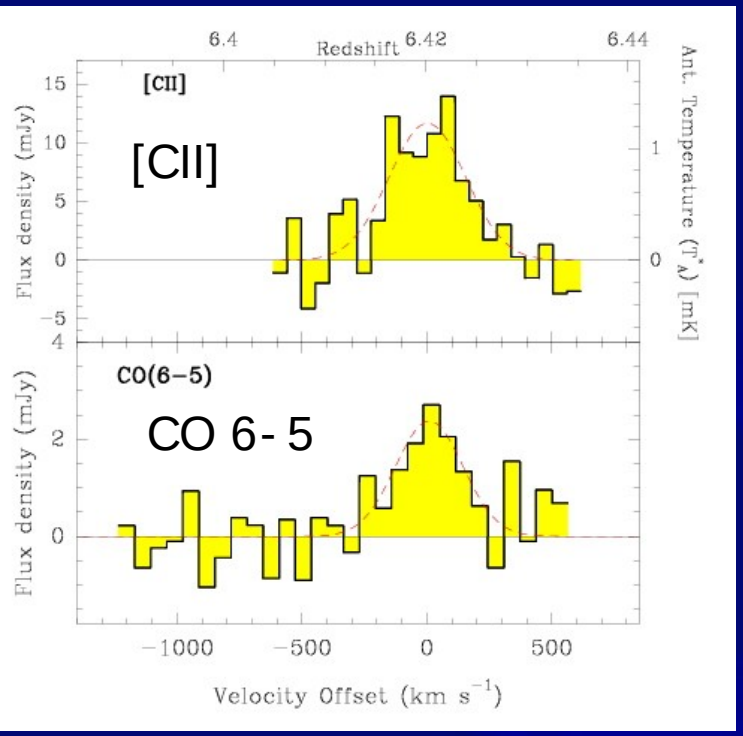
Redshifts, dust, gas masses, plus high res. images of gas dynamics, star formation

SDSS J1148+5251: Dust and molecular gas into cosmic reionization









IRAM

1e9 M_sun in dust, 1e10 M_sun in mol. gas =>

Hyper luminous IR galaxy (FIR = 1e13 L_sun) : SFR = 1e3 M_sun/yr ?

Coeval formation of SMBH/ Galaxy?

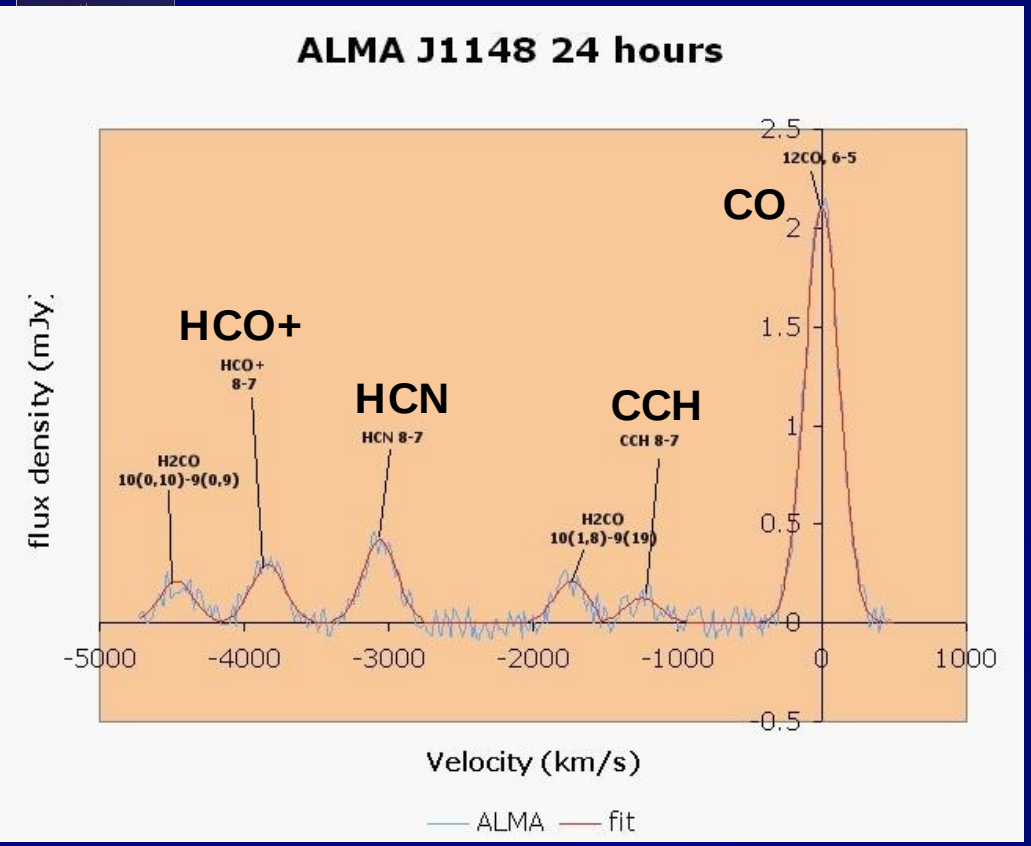
Dust formation by massive stars?

Break-down of M-σ relation at high z?

Early enrichment of heavy elements (z_sf > 8)

Integration times: hours to days on HLIRGs

ALMA into the EoR

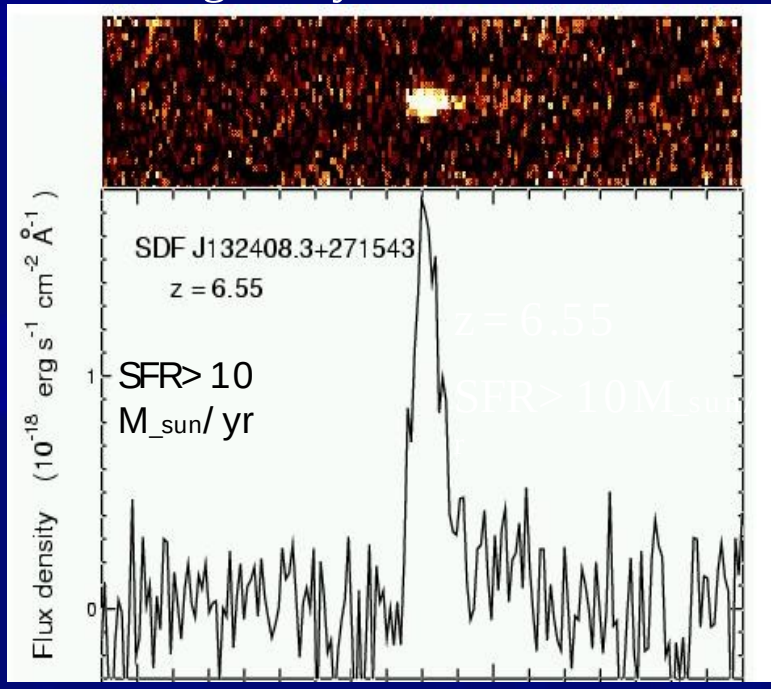


Spectral simulation of J1148+5251

Detect dust emission in **1sec** (5σ) at 250 GHz

Detect multiple lines, molecules per band => detailed astrochemistry

Image dust and gas at sub-kpc resolution – gas dynamics!

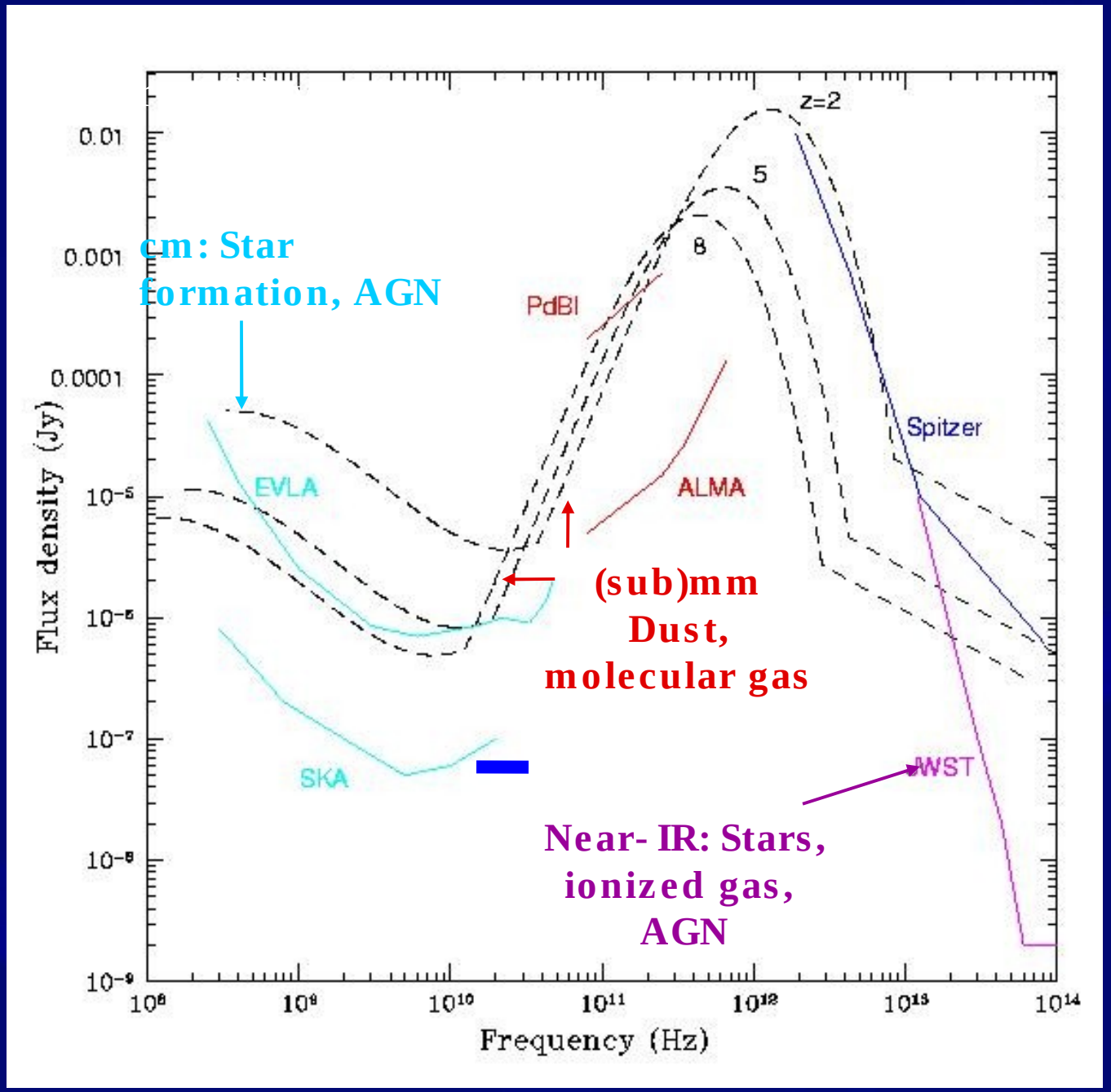


Studying 1st galaxies

Detect 'normal' (eg. Ly α), star forming galaxies, like M51, at z > 6, in few hours

Determine redshifts directly from mm spectroscopy

ALMA – panchromatic view of galaxy formation



http://www.oan.es/alma2006/

MINISTERIO DE FOMENTO

Atacama Large Millimeter Array

MINISTERIO DE EDUCACIÓN Y CIENCIA

Science with ALMA: a new era for Astrophysics

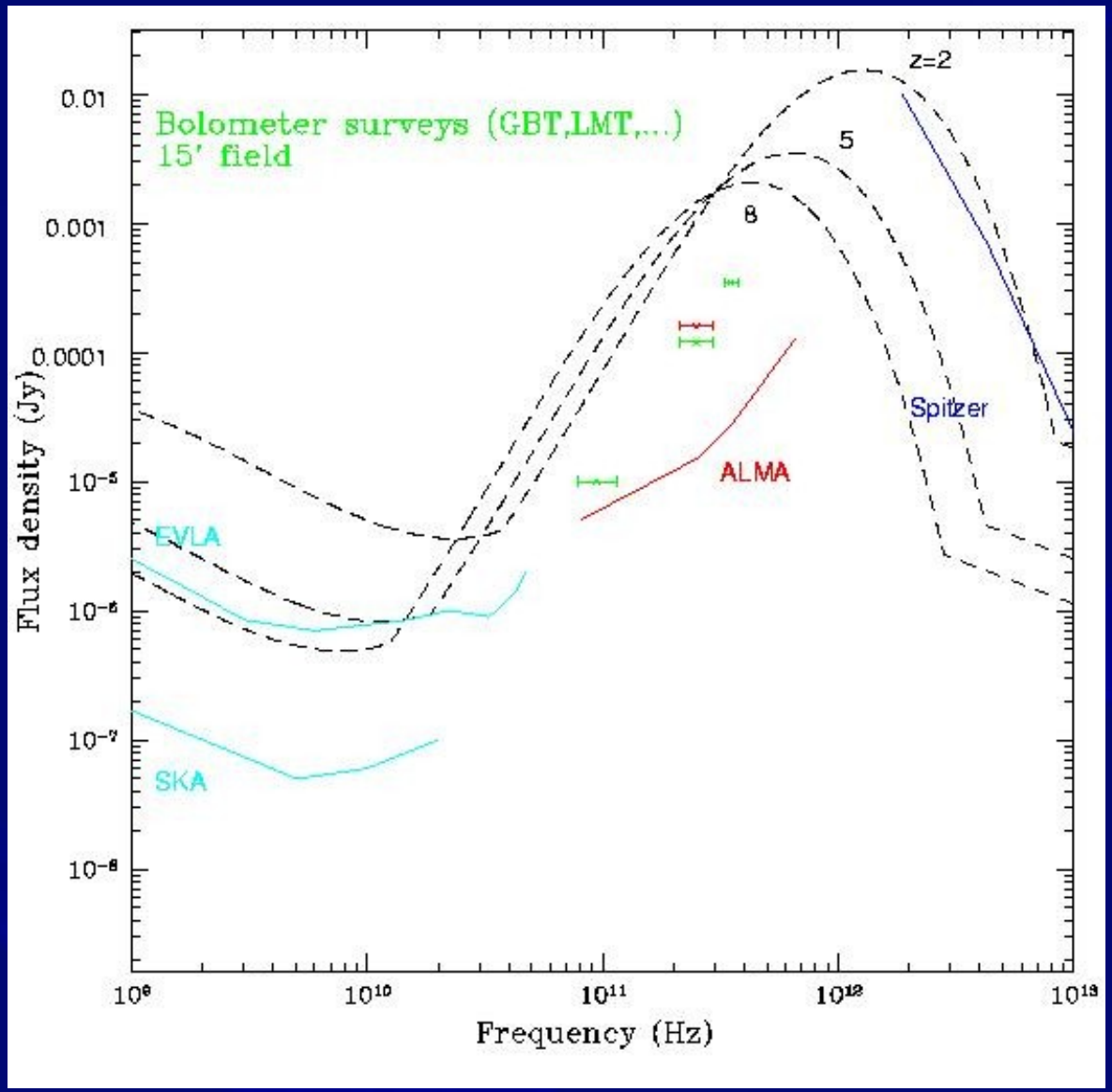
International Conference, 2006

13 - 16 November 2006

Madrid, Spain

END SHOW

Very wide field surveys: role of bolometer cameras



Bolometers (+ EVLA, Spitzer): survey large areas to sub-mJy sensitivity

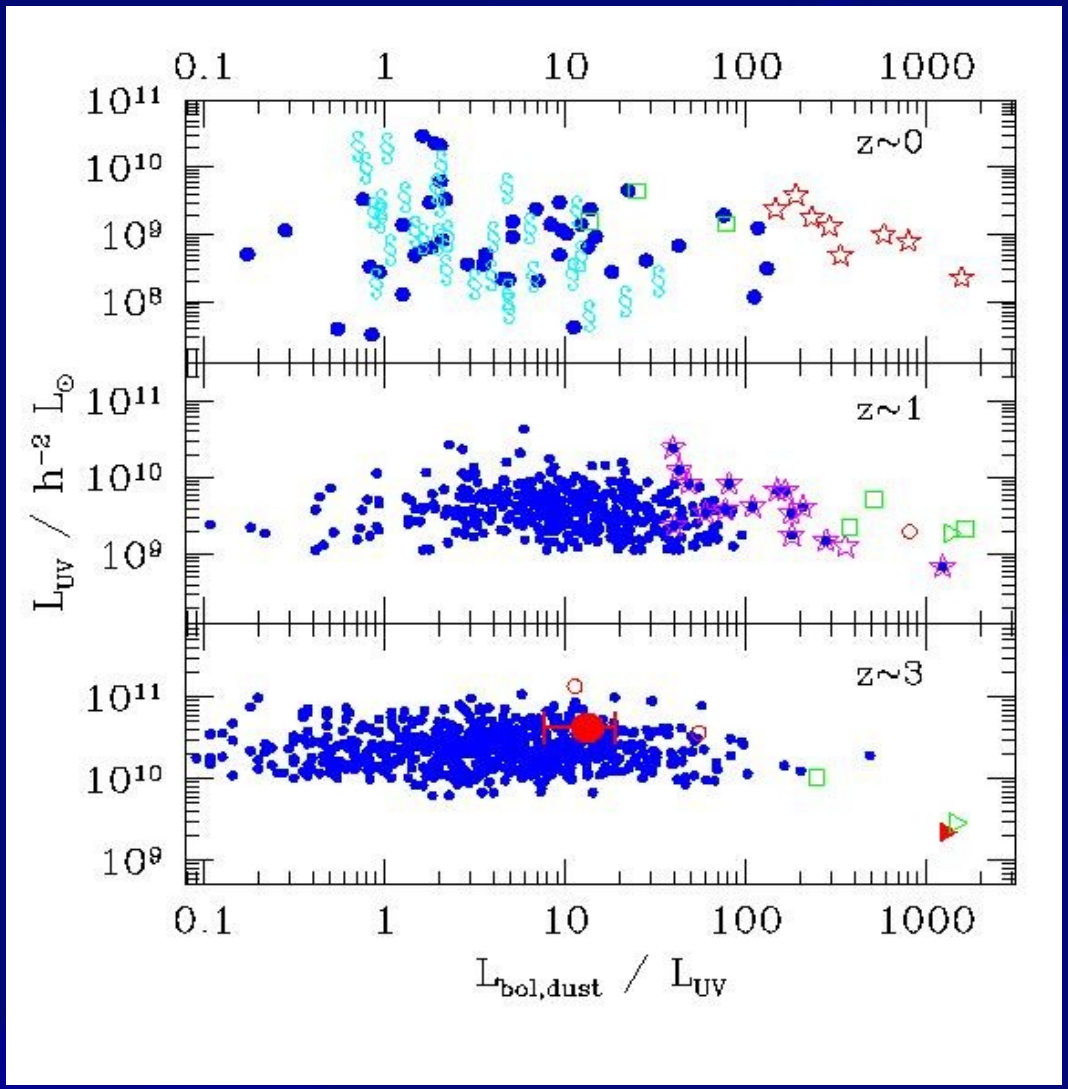
ALMA: detailed SED and CO follow-up

ALMA: uJy, narrow field surveys

Summary of detailed requirements

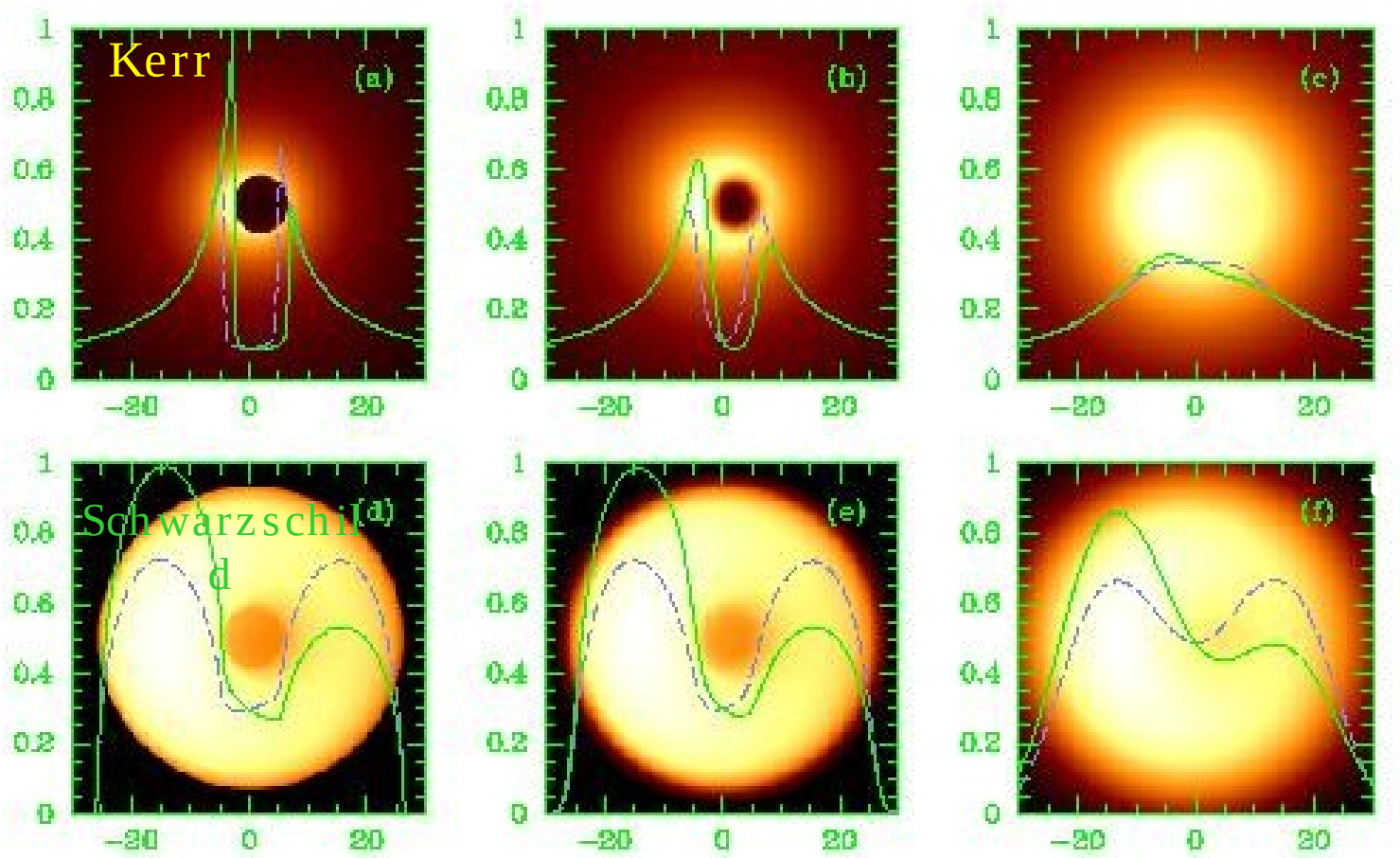
Frequency	30 to 950 GHz (initially only 84-720 GHz)
Bandwidth	8 GHz, fully tunable
Spectral resolution	31.5 kHz (0.01 km/s) at 100 GHz
Angular resolution	1.4 to 0.015" at 300 GHz
Dynamic range	10000:1 (spectral); 50000:1 (imaging)
Flux sensitivity	0.2 mJy in 1 min at 345 GHz (median conditions)
Antenna complement	64 antennas of 12m diameter
Polarization	All cross products simultaneously

UV selected galaxies – large range in bolometric luminosity, but little correlation of L_{uv} and L_{bol}



Adelberger 2000

Millimeter VLBI – Imaging the Galactic center black hole (Falcke 2000)



Model: opt. thin synch

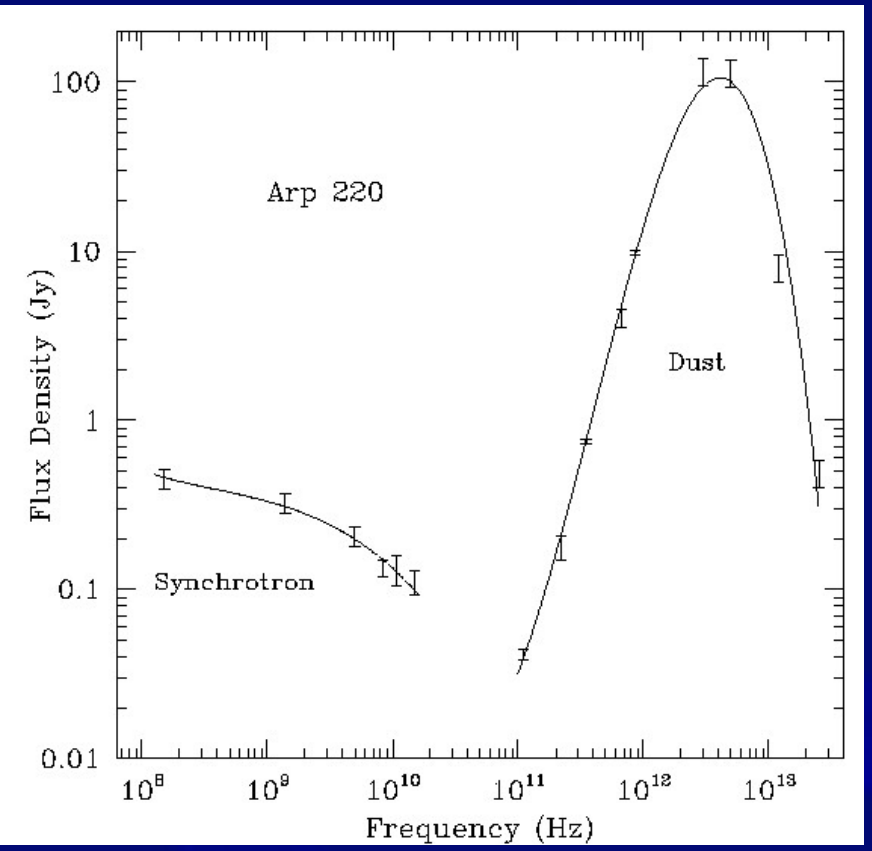
0.6 mm VLBI

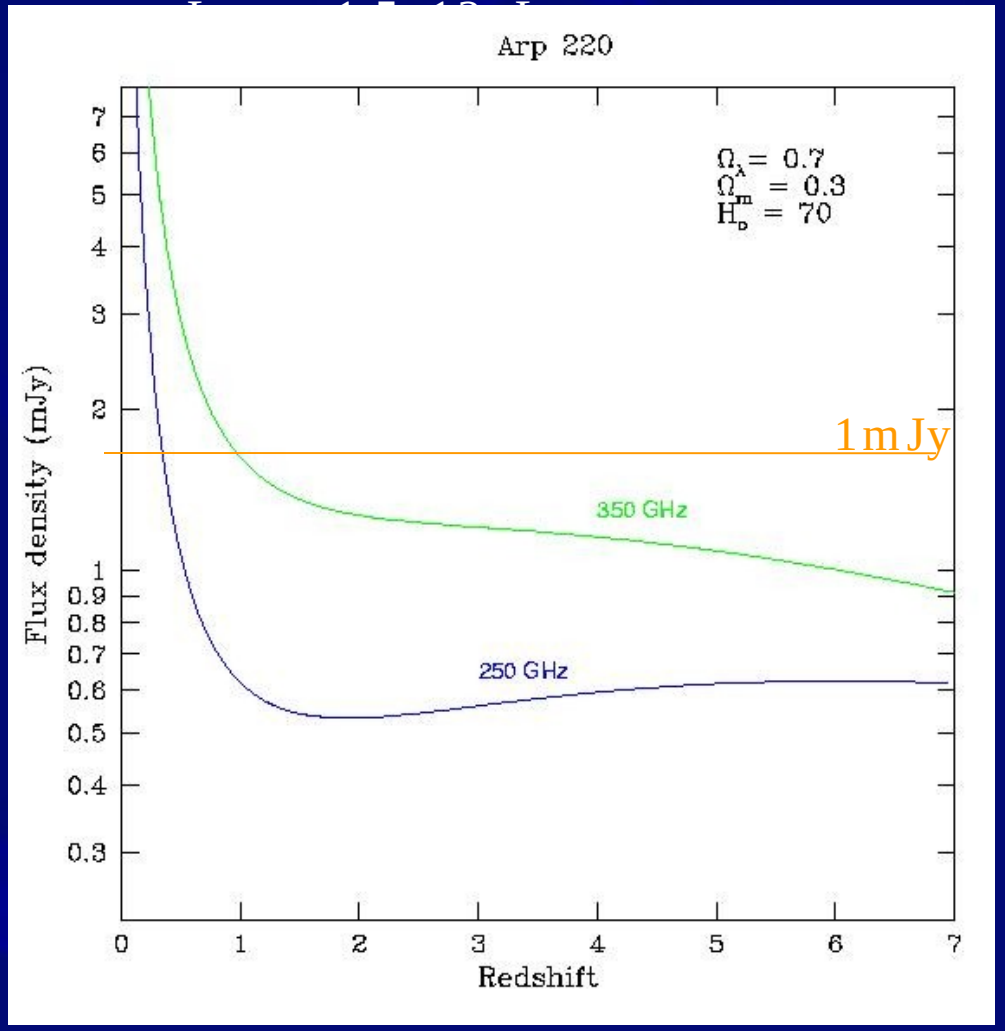
16uas res

1.3 mm VLBI

33 uas res

Birth of Galaxies: Magic of (sub)mm





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M_dyn (r= 2.5kpc) = 2.5e10 M_sun

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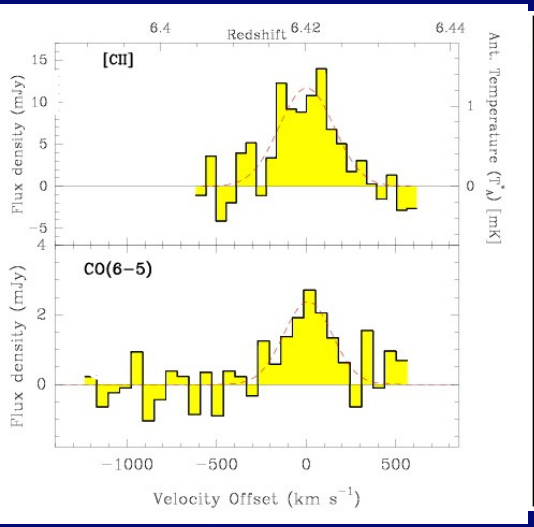

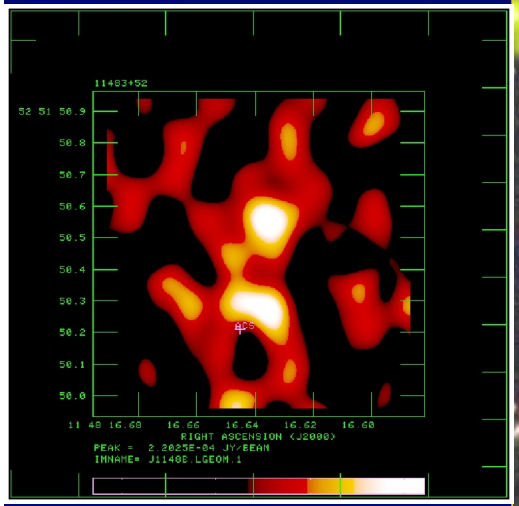

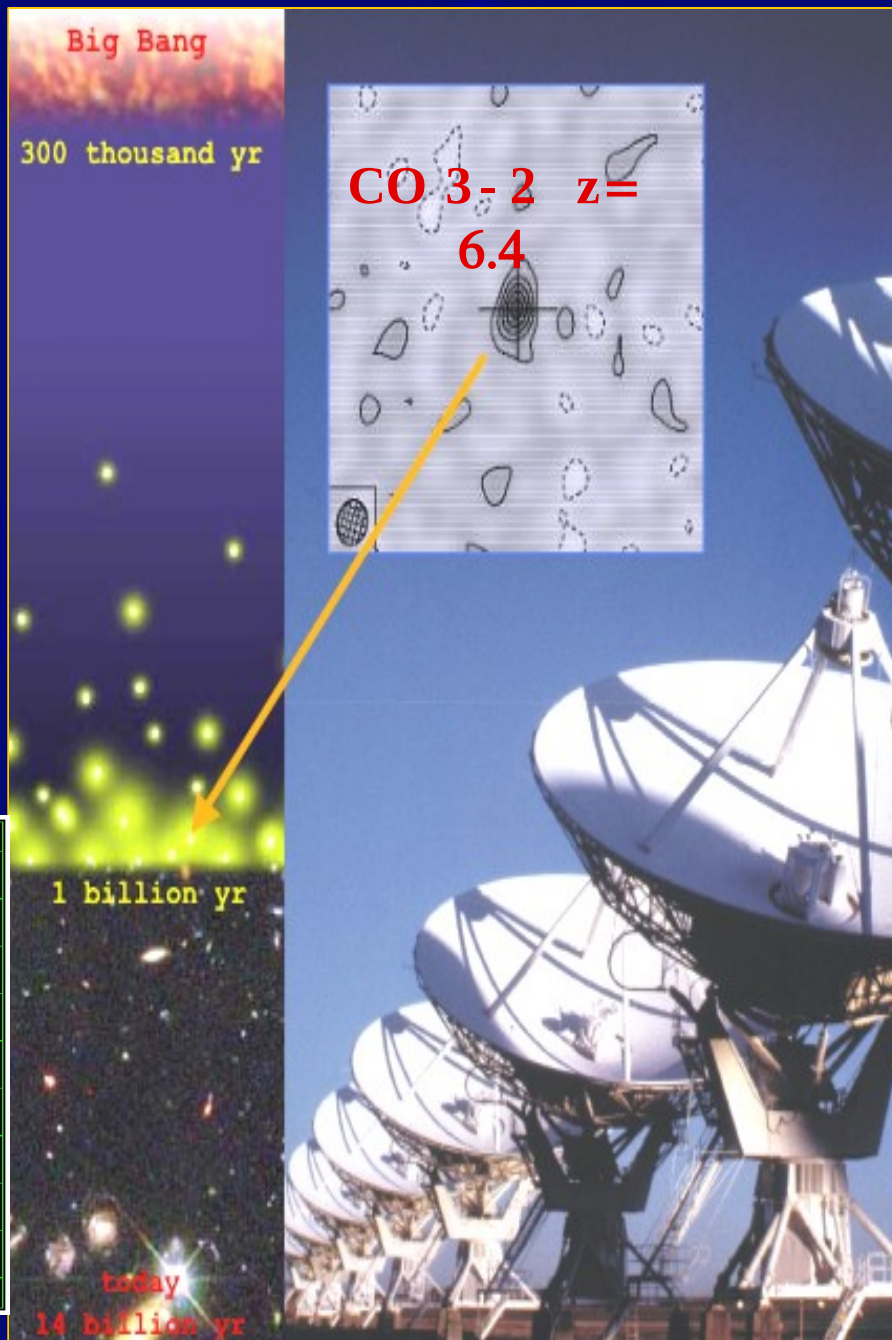

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