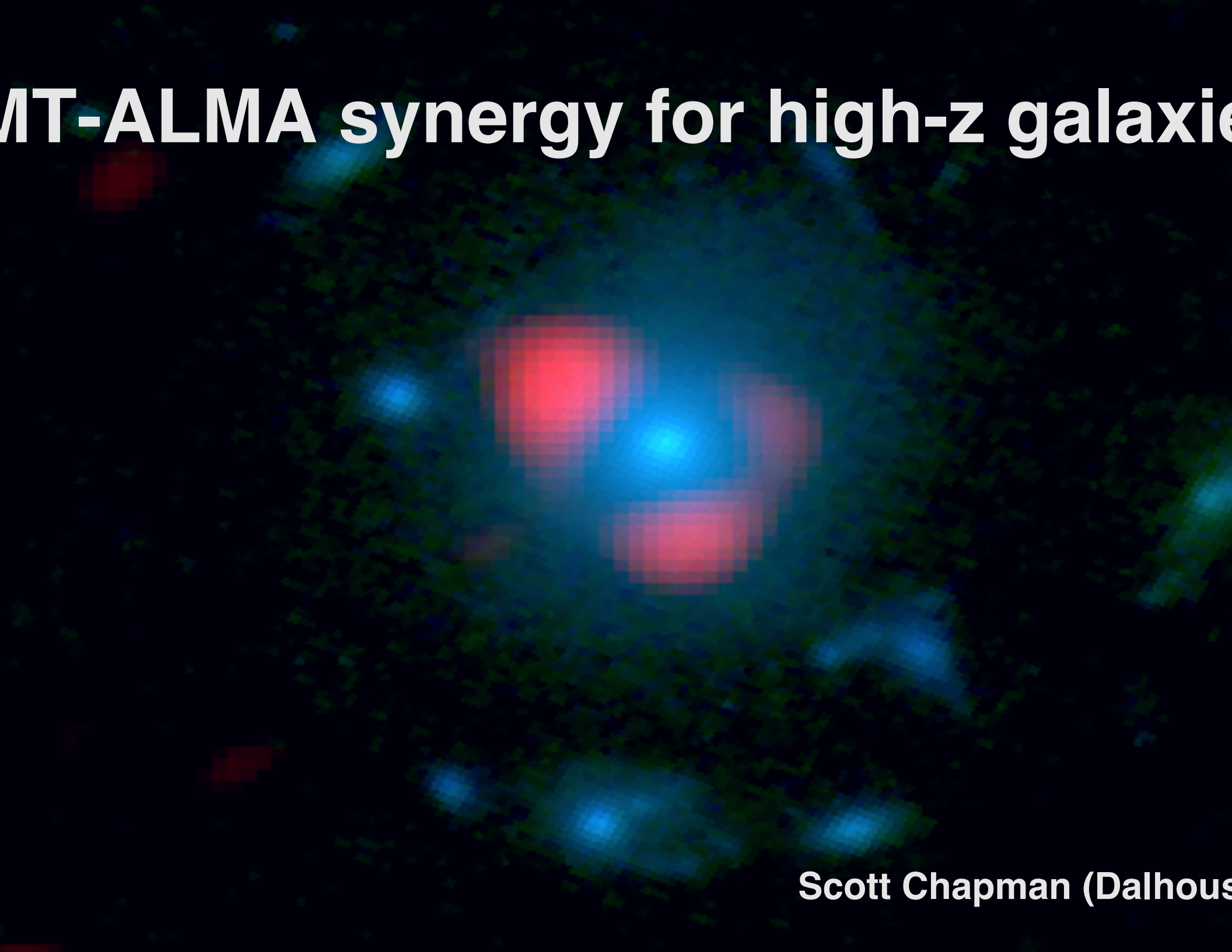
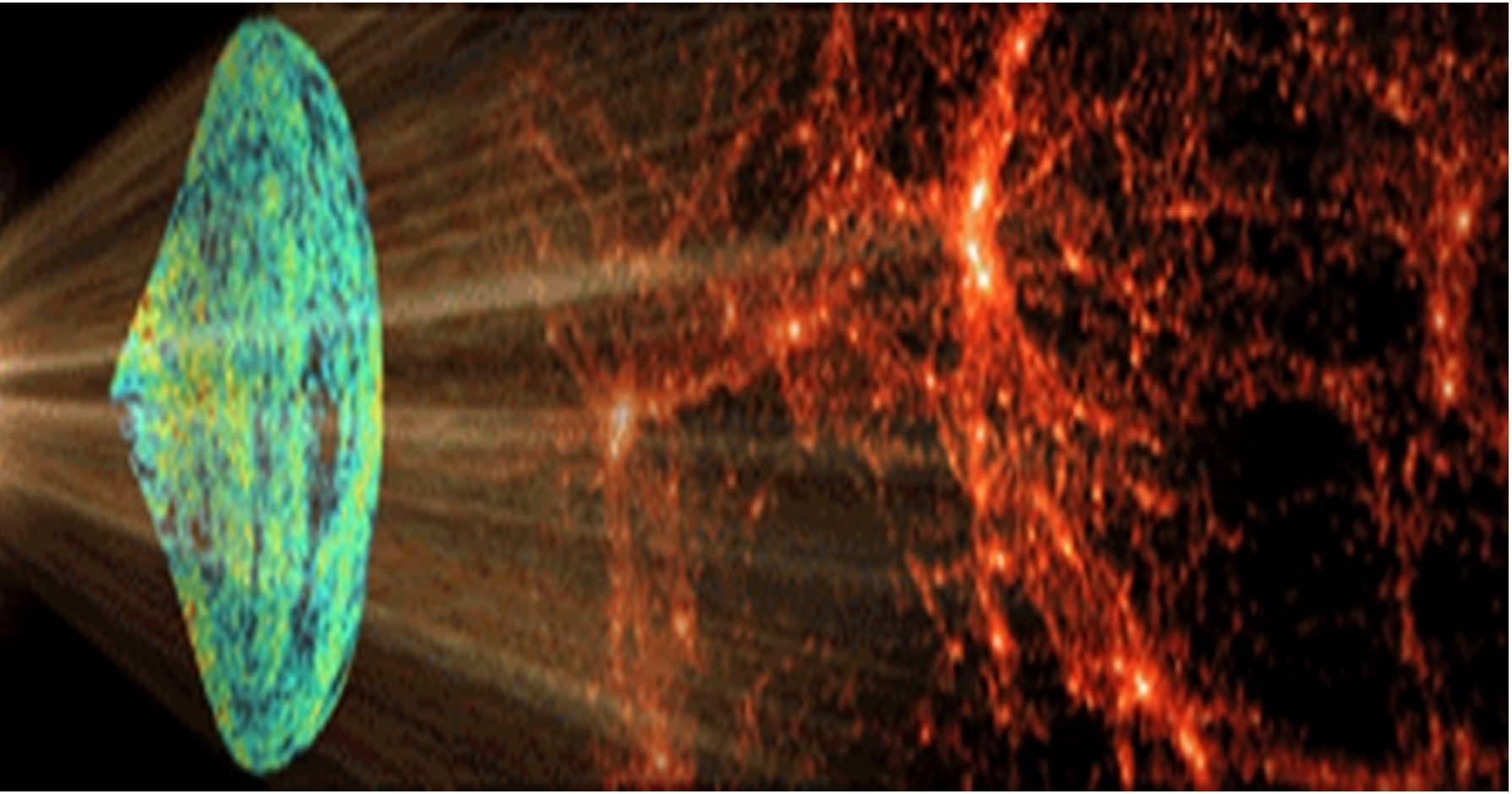
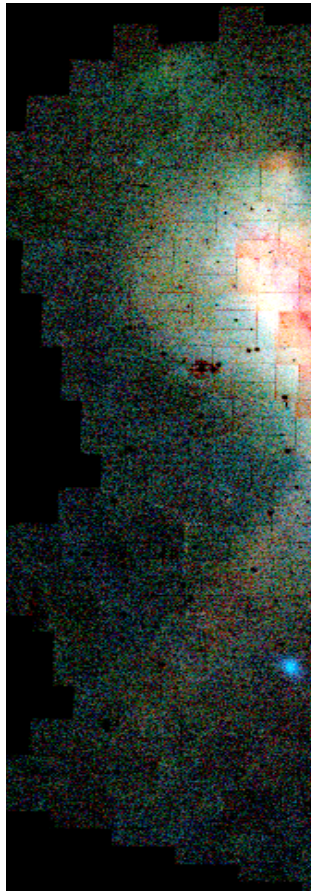
MT-ALMA synergy for high-z galaxie



Scott Chapman (Dalhous

en are the galaxy components assembled?)





Big Bang … Cosmic Microwave Background …
… Galaxy Formation and Evolution … Fossil Records today

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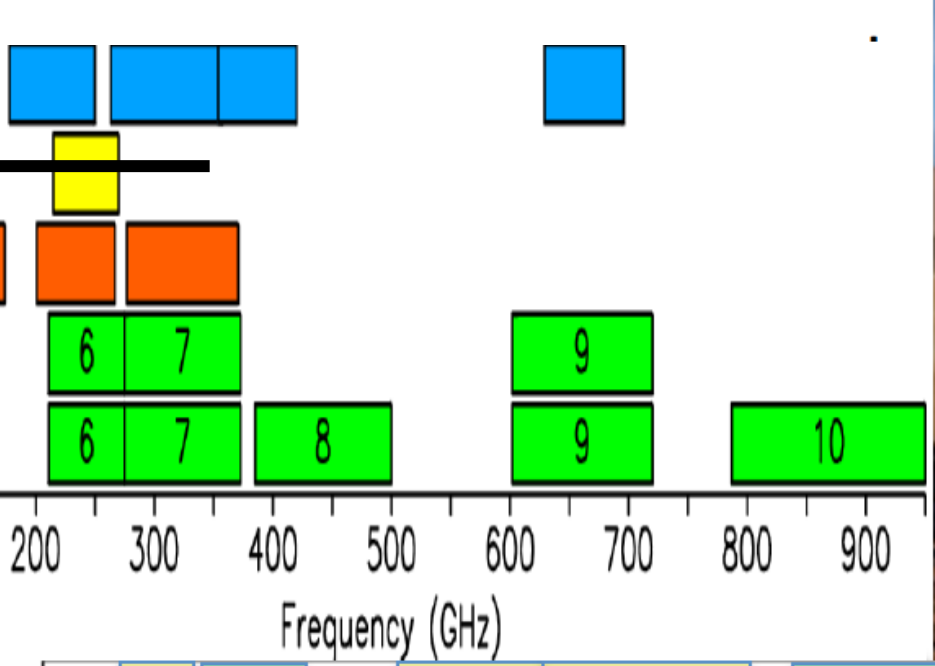
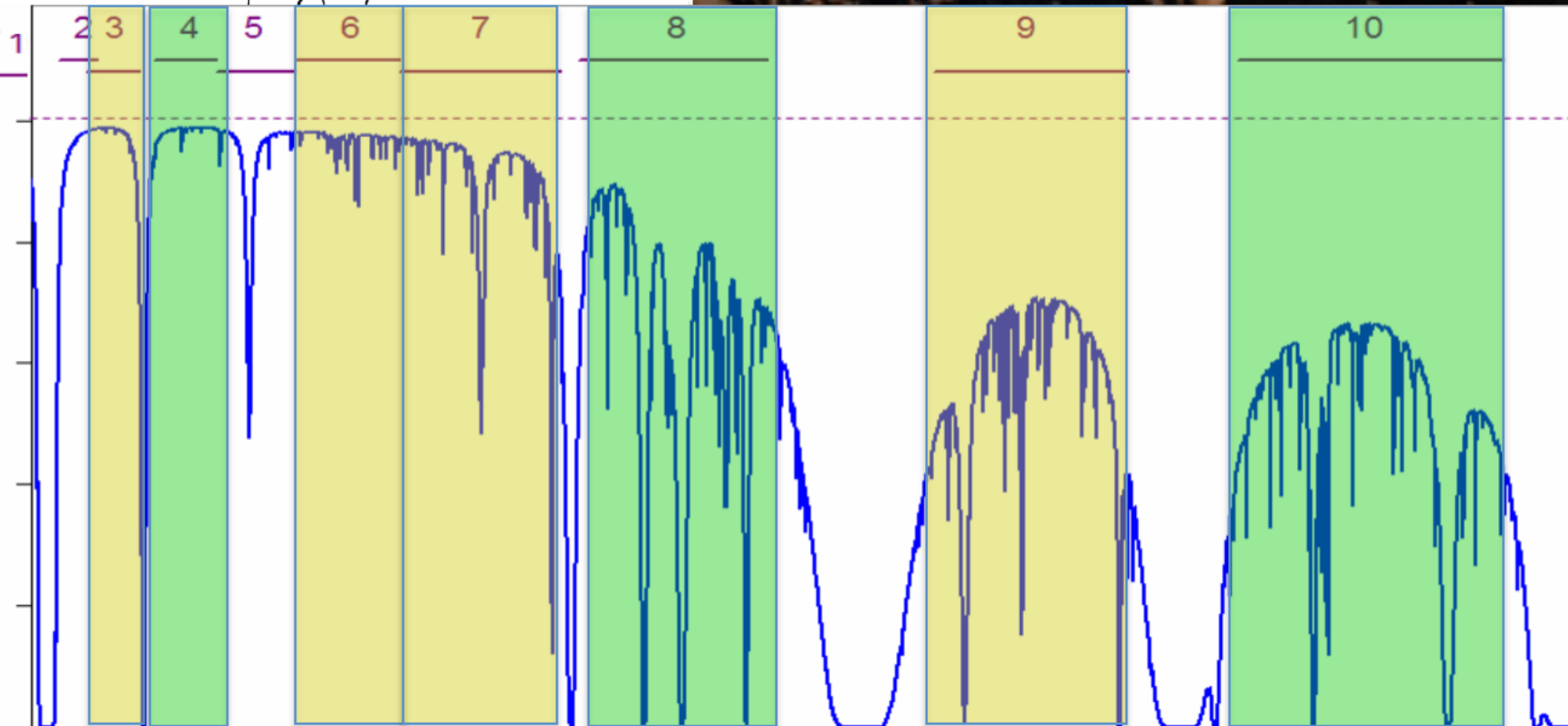
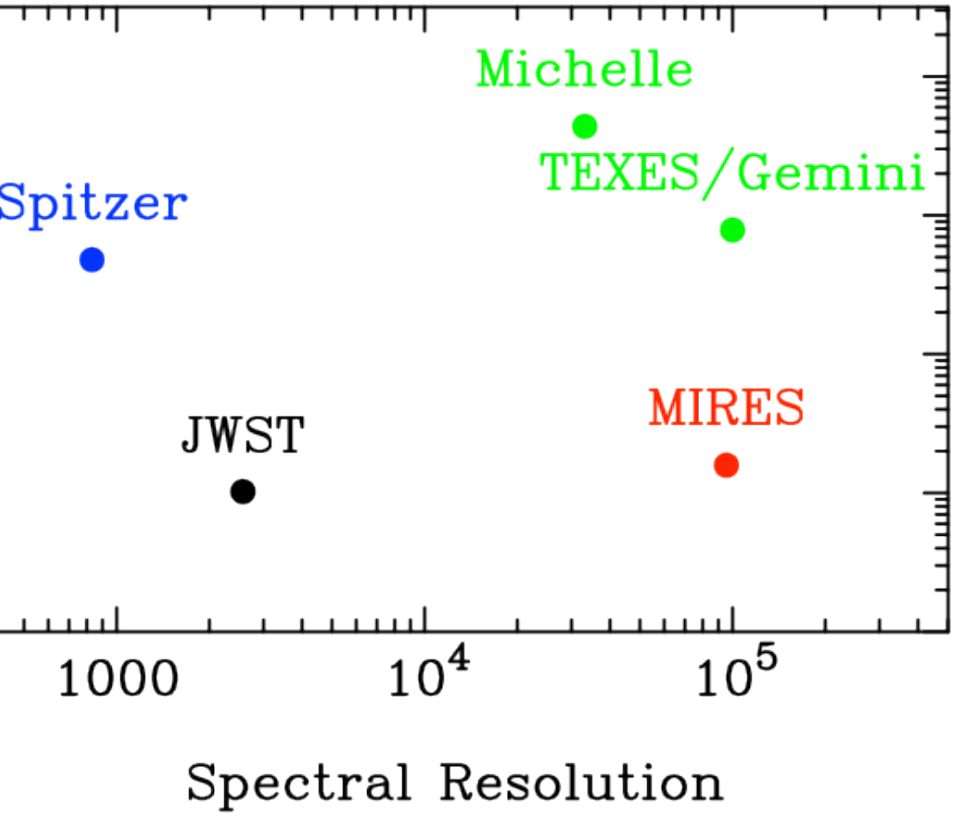
mm/Far-IR is a superb probe of forming galaxies
al Galaxies (like Andromeda) are ideal laboratory to study

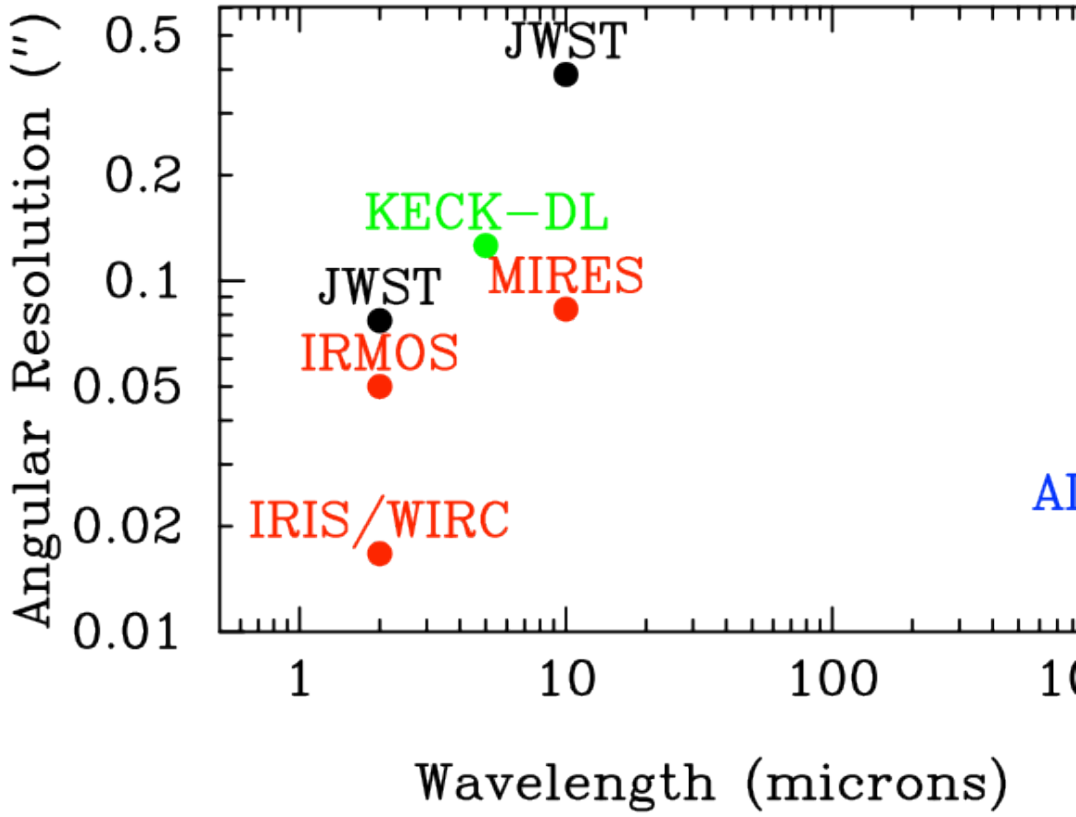

6
7
9
6
7
8
9
10
200
300
400
500
600
700
800
900
Frequency (GHz)


1
2
3
4
5
6
7
8
9
10

Space/IR and ALMA

(TMT capabilities are shown in red)





TMT/MIRES will have comparable spectral line sensitivity (NELF) to frared space missions with a much higher spectral resolution

The angular resolution of TMT ins nicely complements that of JWST and ALMA

TMT is a "near IR A

IA & TMT

FIR – submm- mm - cm

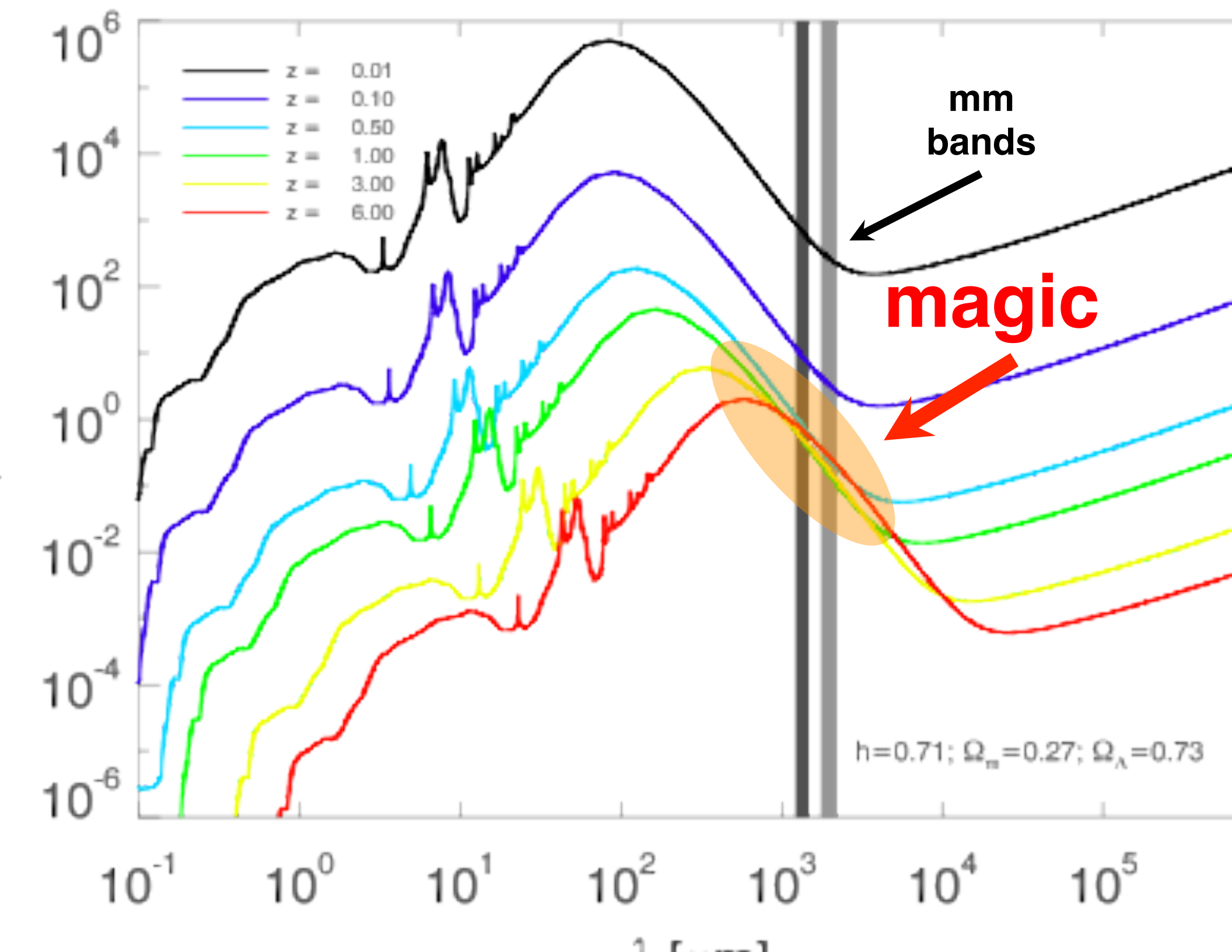
Optical – NIR – mid I

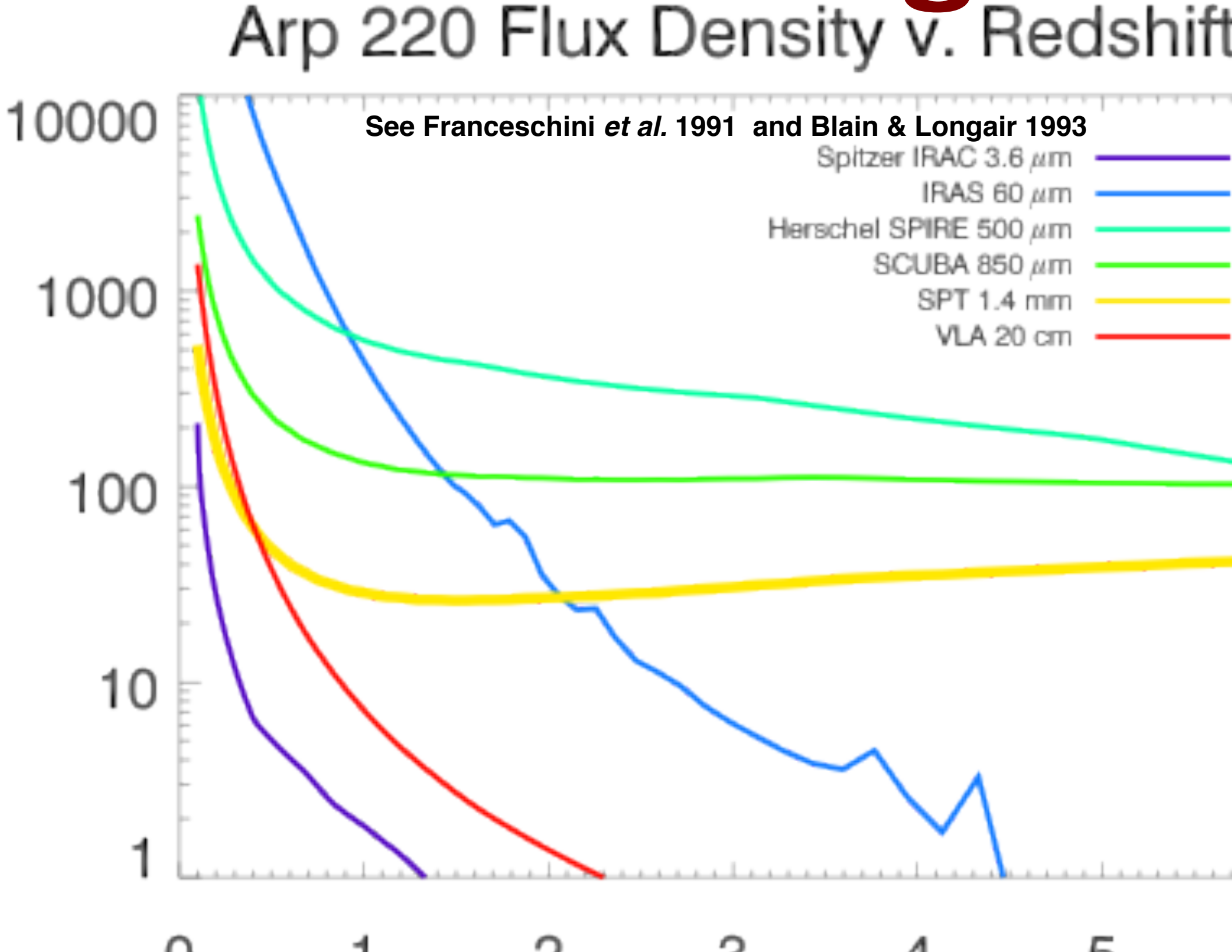
	ALMA	TMT
length ent)	315 μm – 3529 μm	0.3 μm – 2.5 μm
(eventual)	187 μm – 9677 μm	0.3 μm – 28 μm
lar Resolution	8 mas * λ/400μm * 10 km / B_{char}	8.3 mas * λ/1μm
ral Resolution	R = 3191 -- 2.7 x 10^7	R = 10 – 10^5

	ALMA	IRIS (0.8-2.5 μm) NFIRAOS	WFOS (0.3-1 μm) Seeing-limited	IRMS (0.8-2.5 μm NFIRAOS
f view	6”-74” + mosaics	3” (IFU) 17” (imaging)	➢ 40 sqarcmin ➢ >500” slits	2’ (46 slits)
al tion	3191 --2.7e7	>3500 5-100 (imaging)	1000-5000 >7500 @0.75”	4660 @0.1 slits

y Forming Galaxies can be very optically
n the most luminous galaxies in the Univ

ALMA ideal to find them
TMT will help understand them


z = 0.01
z = 0.10
z = 0.50
z = 1.00
z = 3.00
z = 6.00
mm bands
magic
h=0.71; Ω_m=0.27; Ω_Λ=0.73
10^6
10^4
10^2
10^0
10^-2
10^-4
10^-6
10^-1
10^0
10^1
10^2
10^3
10^4
10^5

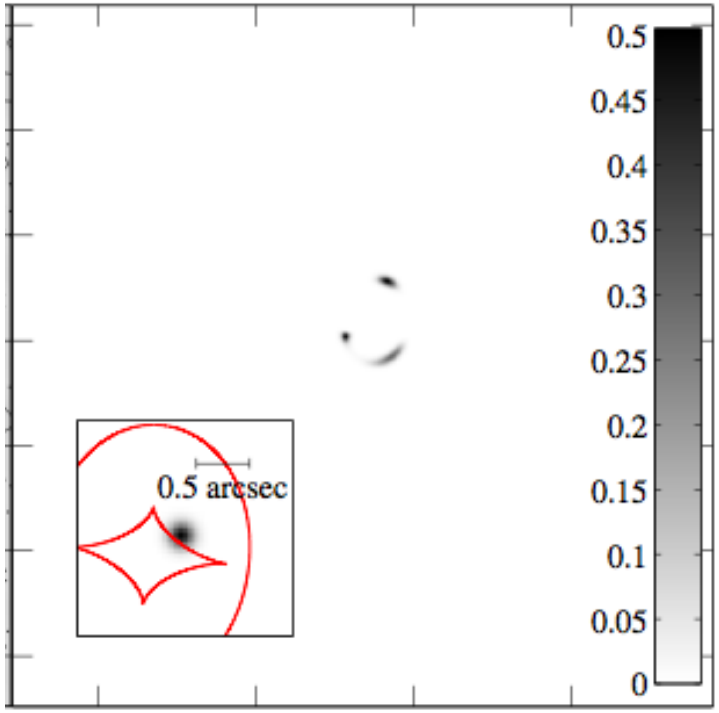

Arp 220 Flux Density v. Redshift
See Franceschini *et al.* 1991 and Blain & Longair 1993
Spitzer IRAC 3.6 μm
IRAS 60 μm
Herschel SPIRE 500 μm
SCUBA 850 μm
SPT 1.4 mm
VLA 20 cm
10000
1000
100
10
1
0
1
2
3
4
5

=150mJy / 5x lensing = 30 mJy ; R_AB>27, H_AB>2

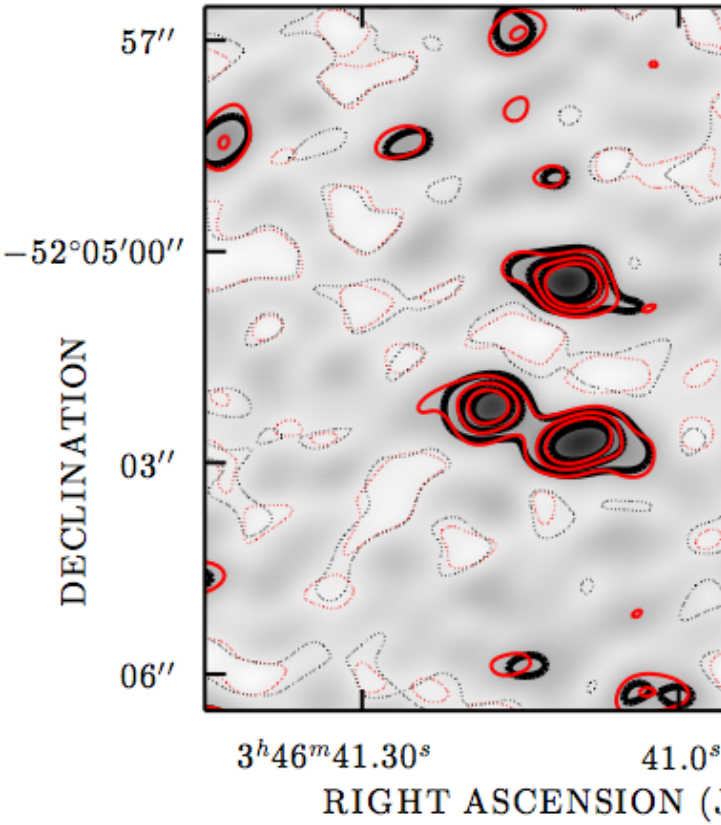
most luminous galaxy in the Universe?

odeling : Hezaveh *et al.* 2012, ApJ

lens model



ALMA extended configuration



odel ALMA U-V plane data with a custom and statistically robust technique

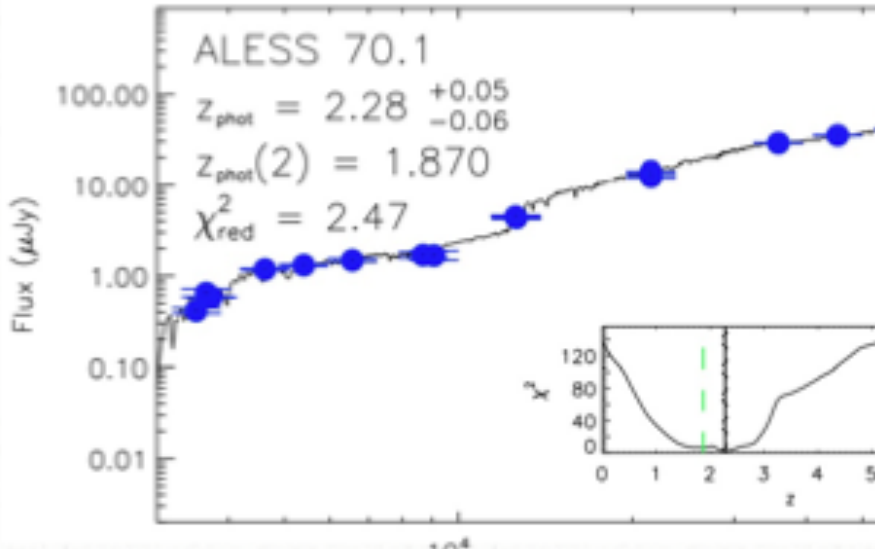
0348 is the most intrinsically luminous SPT-SMG

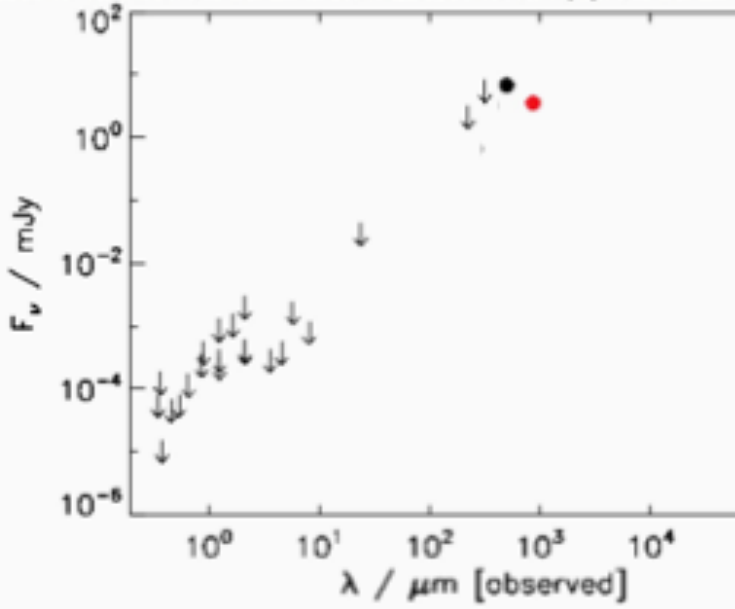

Herschel: 500, 350, 200 μm
12CO
13CO
H2O
H2O+
CI
>10^13 L⊙
SFR > 500 M⊙/yr
SPT-0346-52
~30 mJy

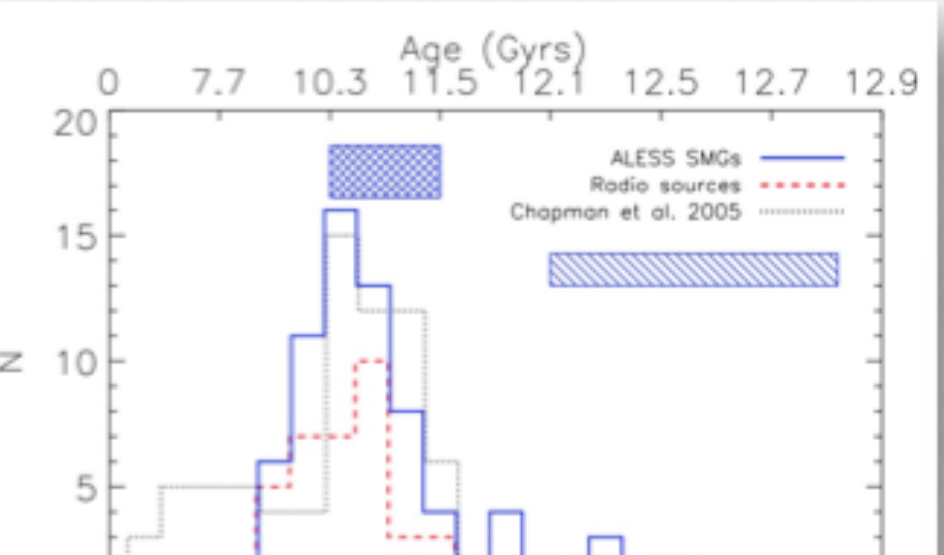
SMG N(z)

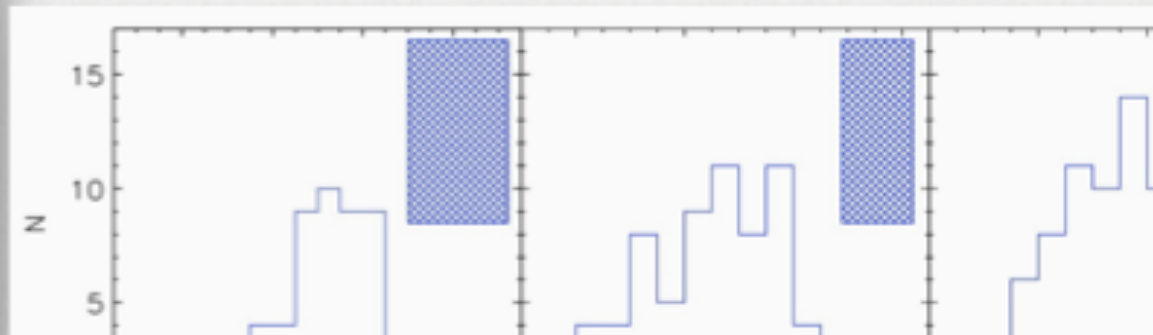
Simpson et al. MNRAS 2014

- Photo-z analysis of 99 MAIN SMGs
- 78/96 (80%) detected >4 filters (av. 14)
- 9 detected in 2-3 filters (stacked SED uggests z~2.5)
- 9 detected in 1/0 filters (but some in FIR)
- rms dz/(1+z)=0.06 for 23 spec-z
- Median <z>=2.4+/-0.1









as Chapman+2005

samples have higher <z>

T can help to understand

s size/redshift evolution.

m Smolcic+12 survey has

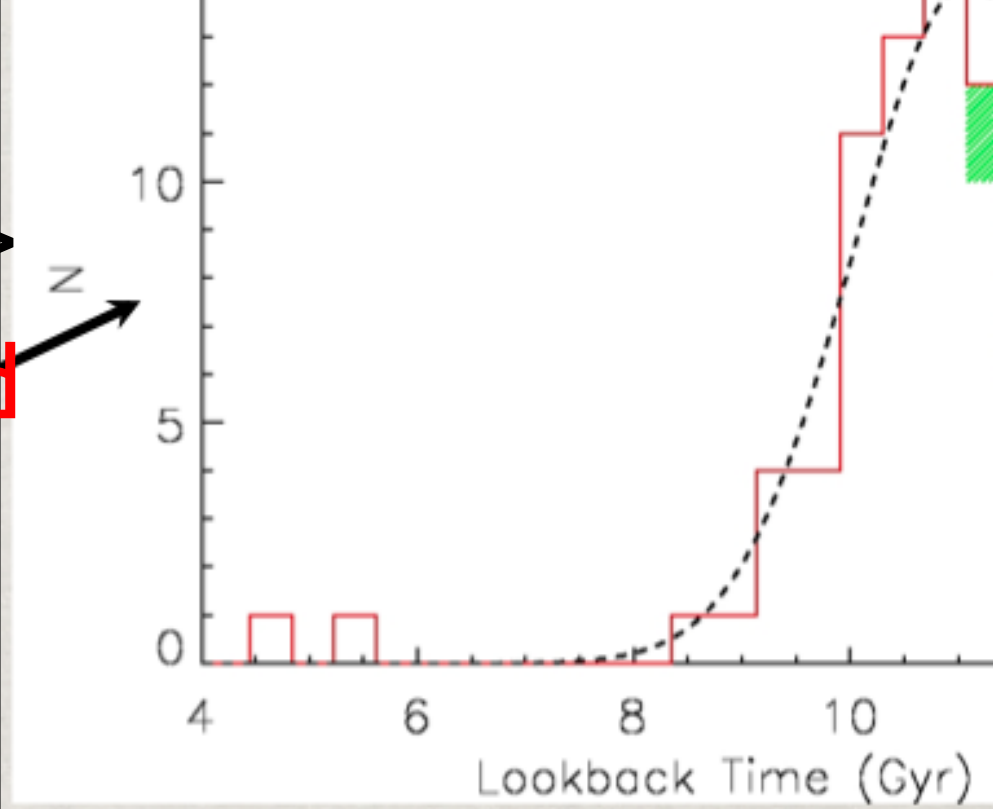
urces at z=2, and <z>=3

ll long wavelength bias?

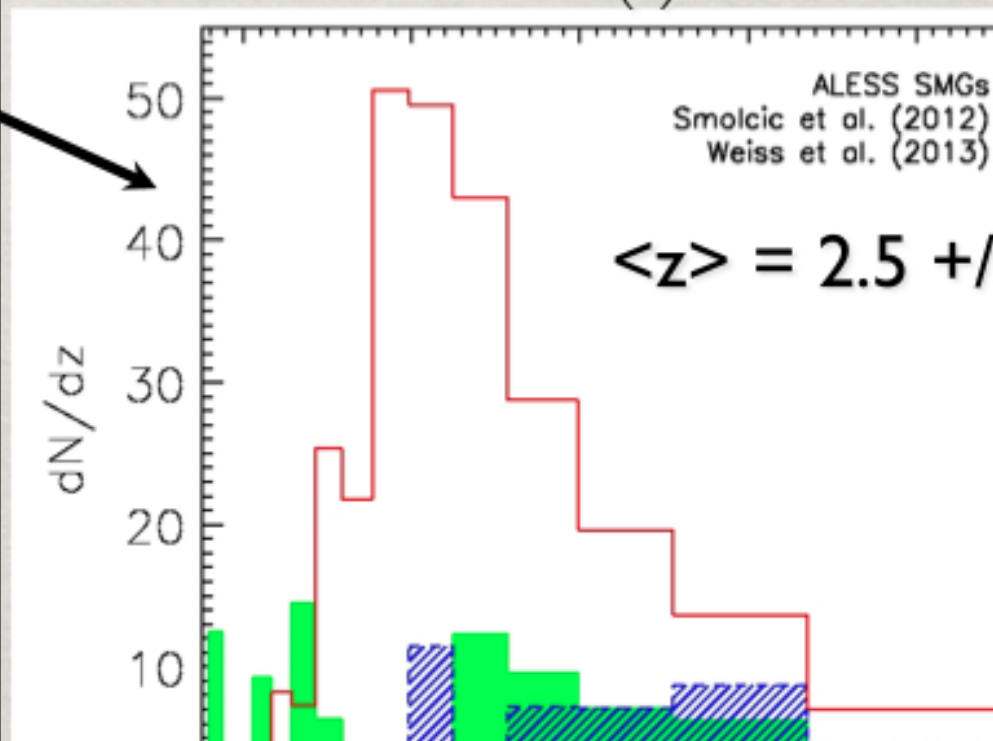
m Vieira+13 survey has

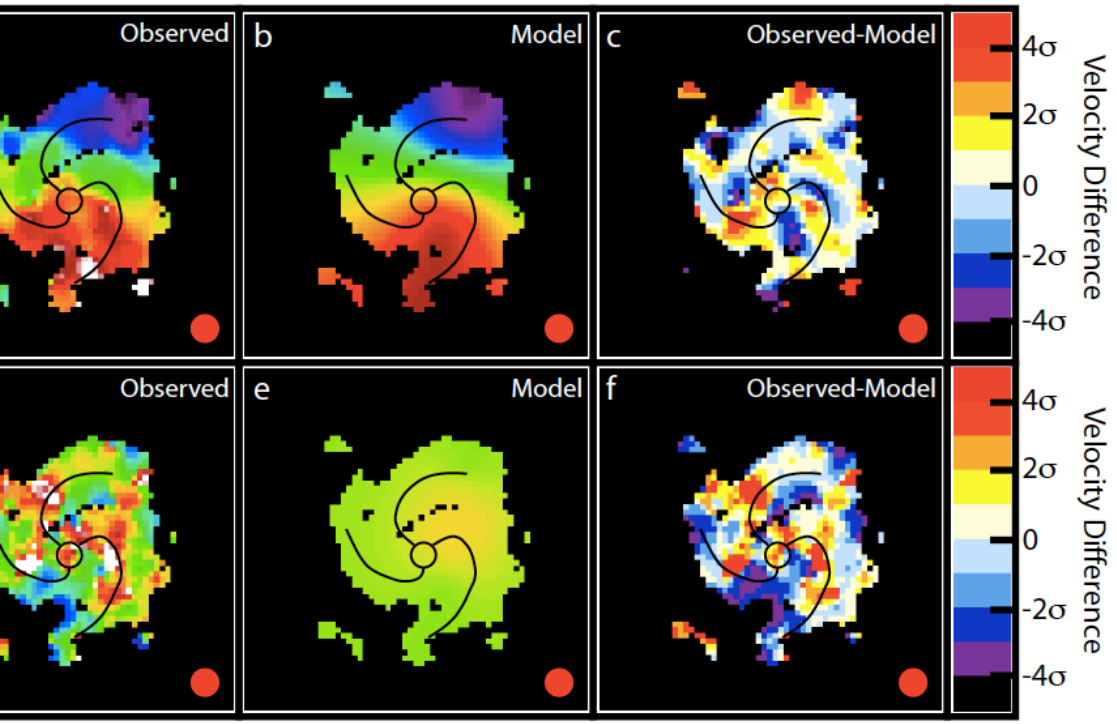
<z>=3.5

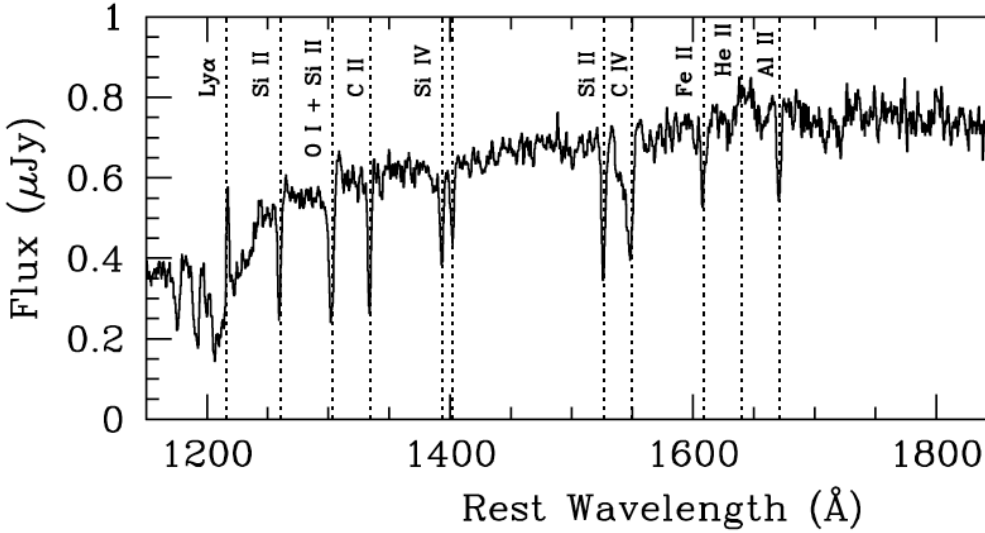
ng wave bias + lens bias?



N(z) for ALESS S





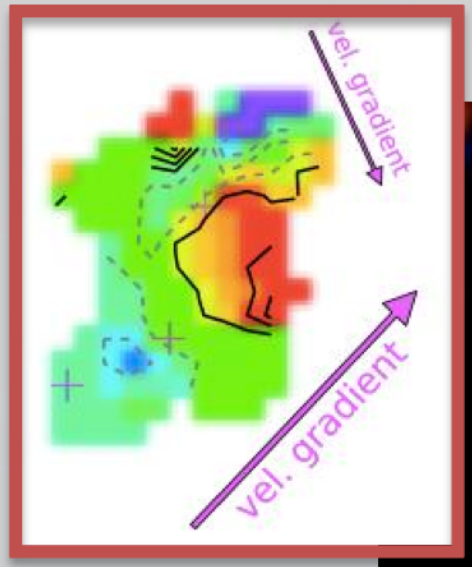


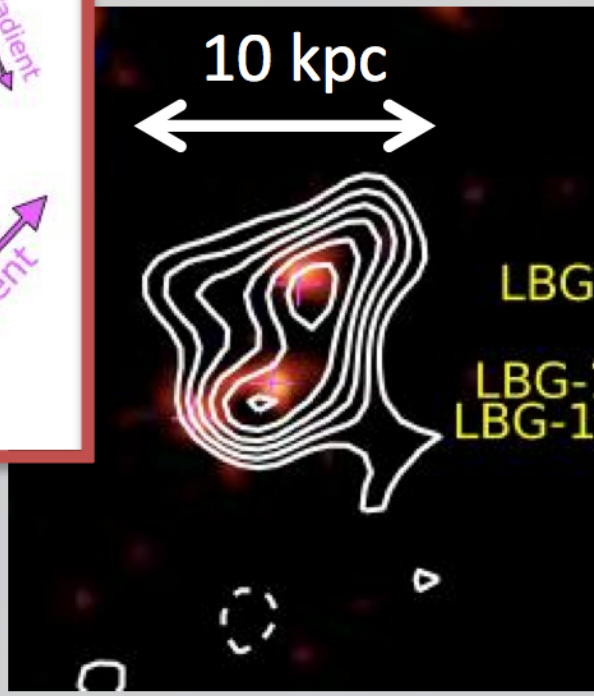
Law et al. 2012a,b

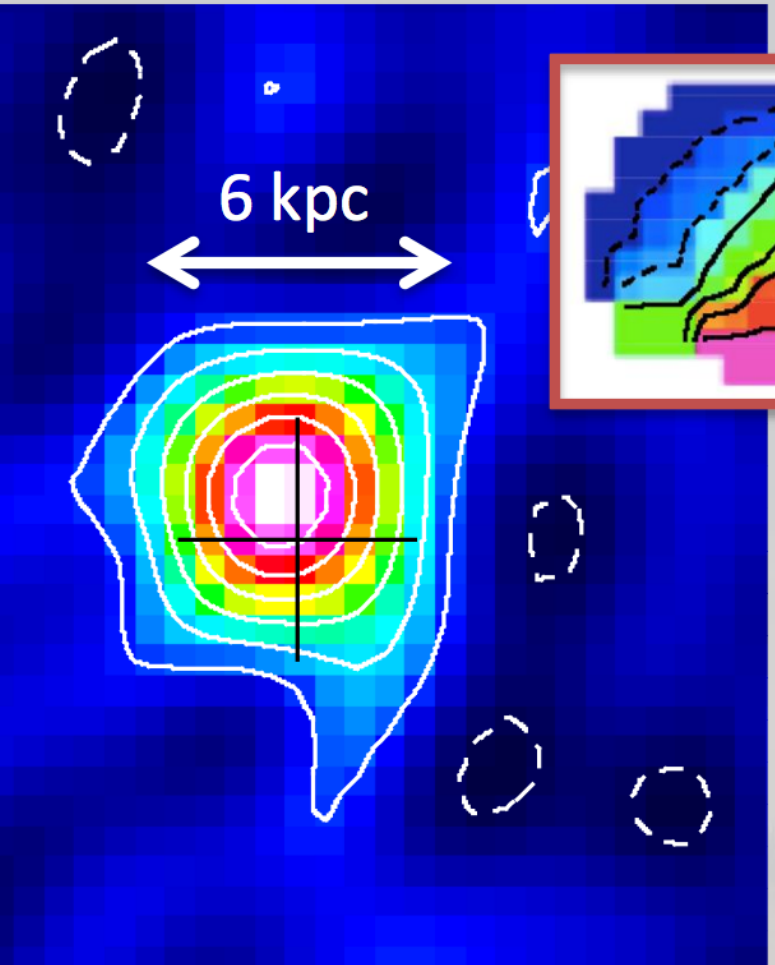
ormous progress has been done observing rest-frame opt
spectra + 2-D kinematics using Keck, LRIS and OSIRIS.

IS: rest optical properties of high-z galaxies; 2' FOV, 2.4" s
WFOS: 20', multiple targets

ALMA [CII] observations *resolve* kinematics of primordial galaxies

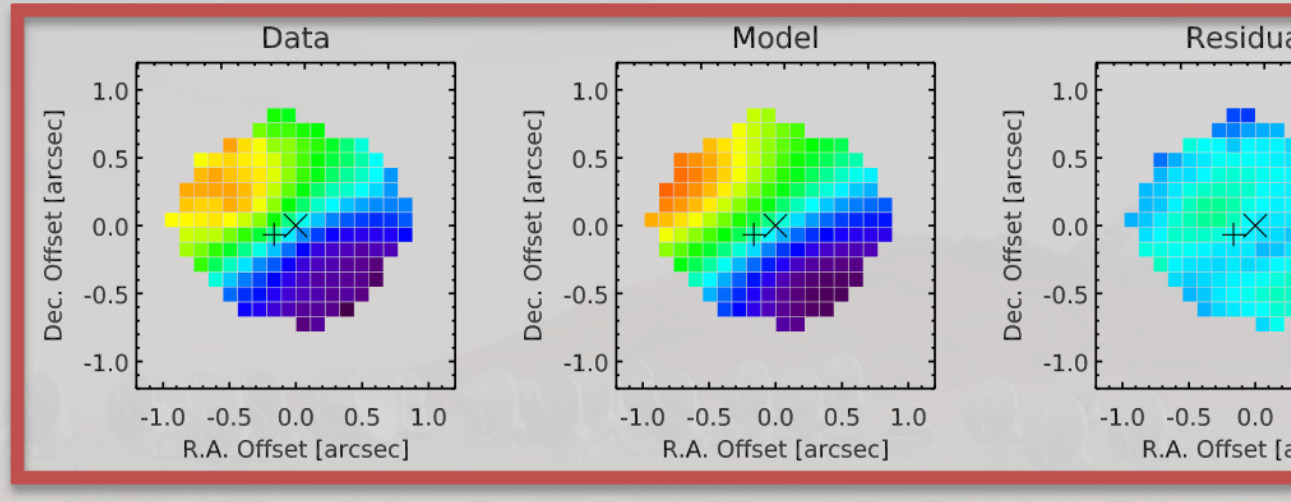






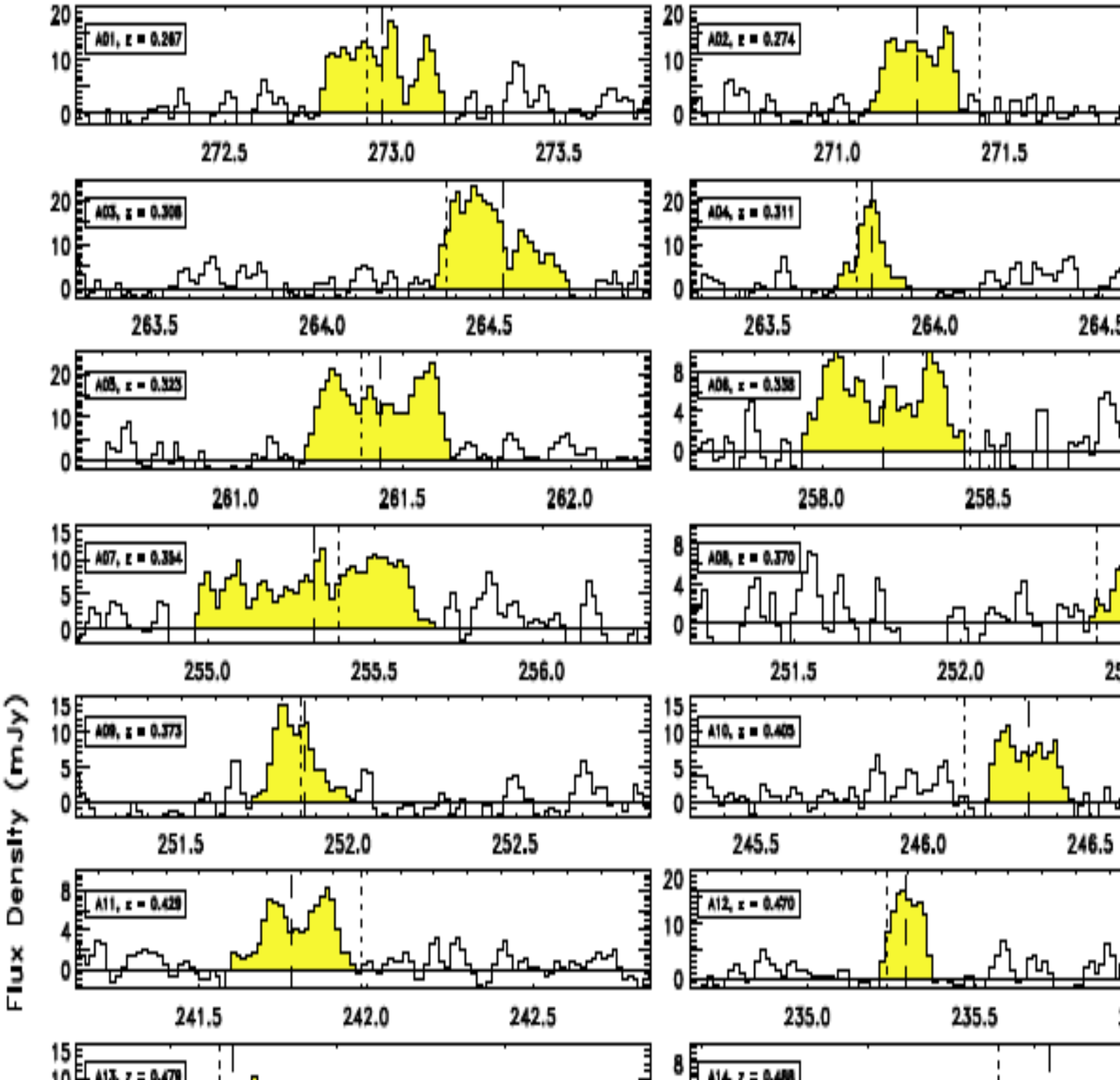
"typical" star forming galaxy at

Rieche



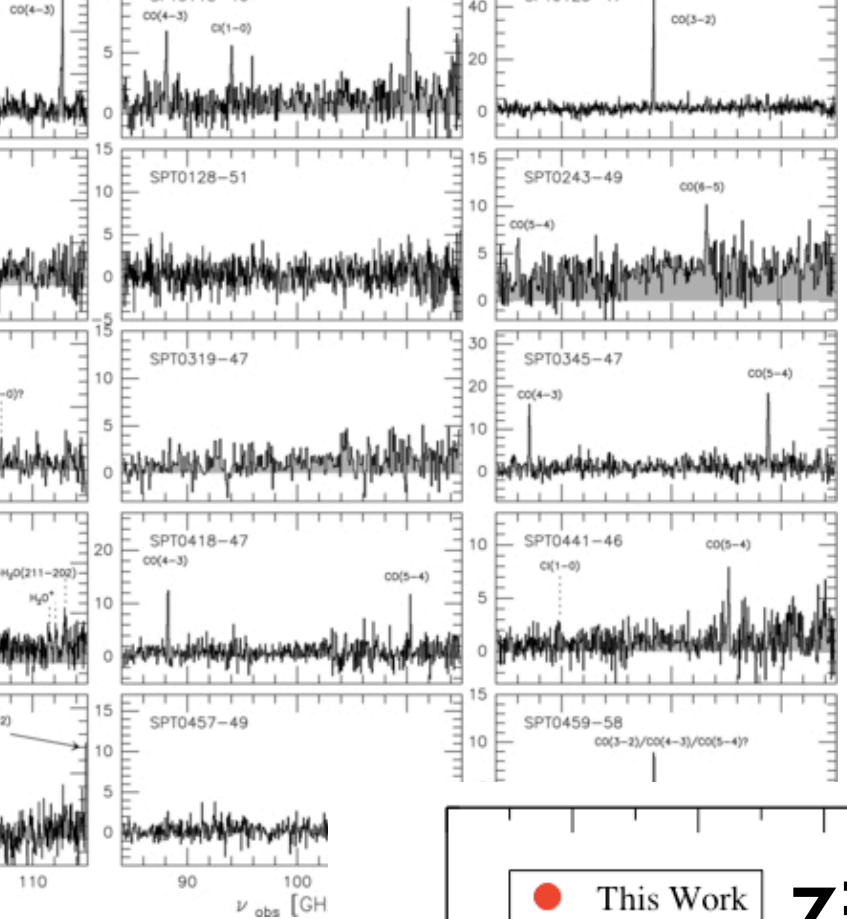
Cyc 1 –
IRGs
d in CO at
1 in 10-30
er target.

samples
one now



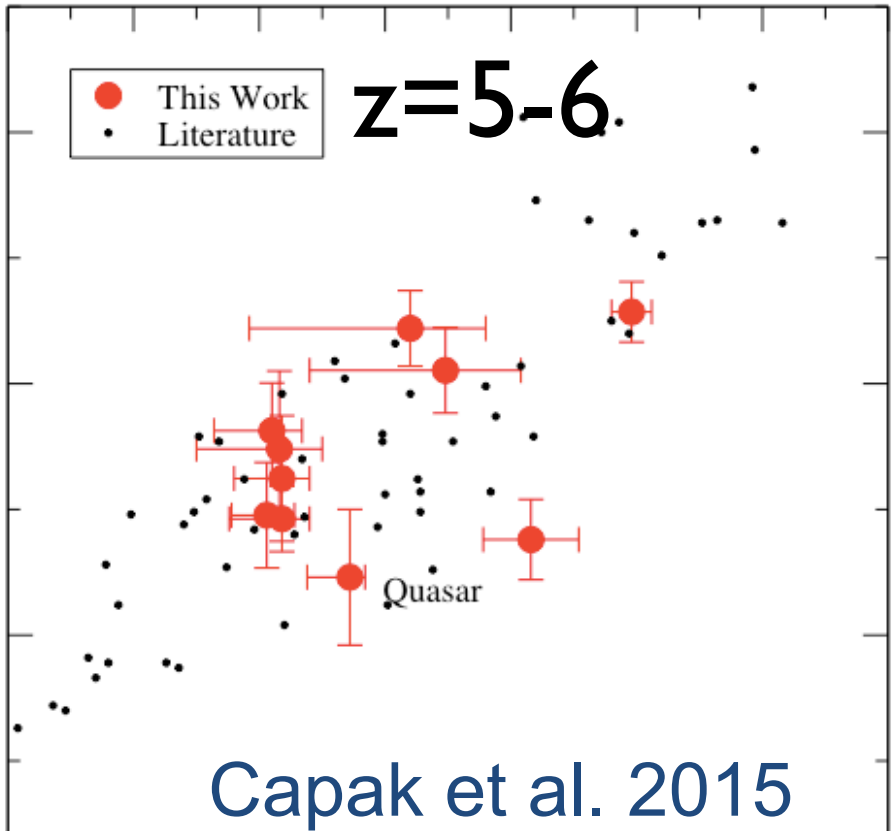
for understanding the SFR d
evolution and assembly of d

- Gas measurements require
int times but can sample all
redshifts using molecular an
atomic lines!



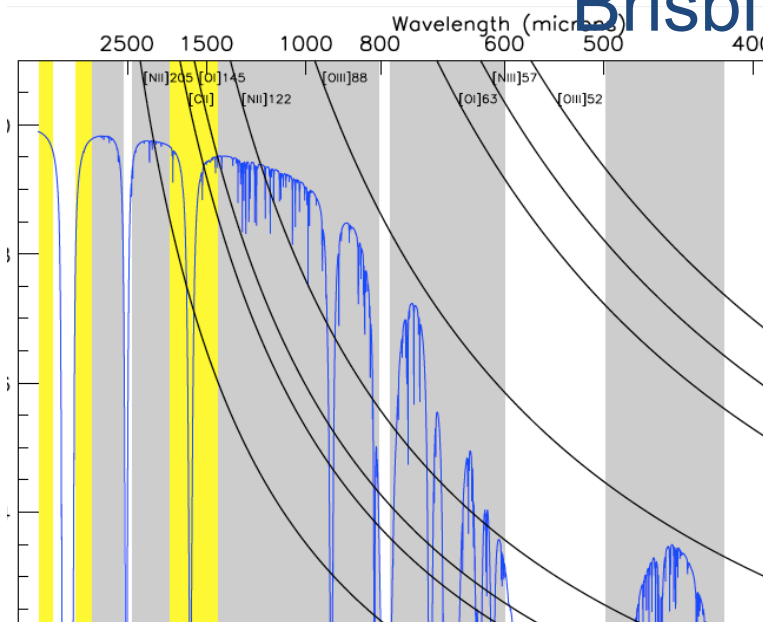
d SMGs
al. 2013

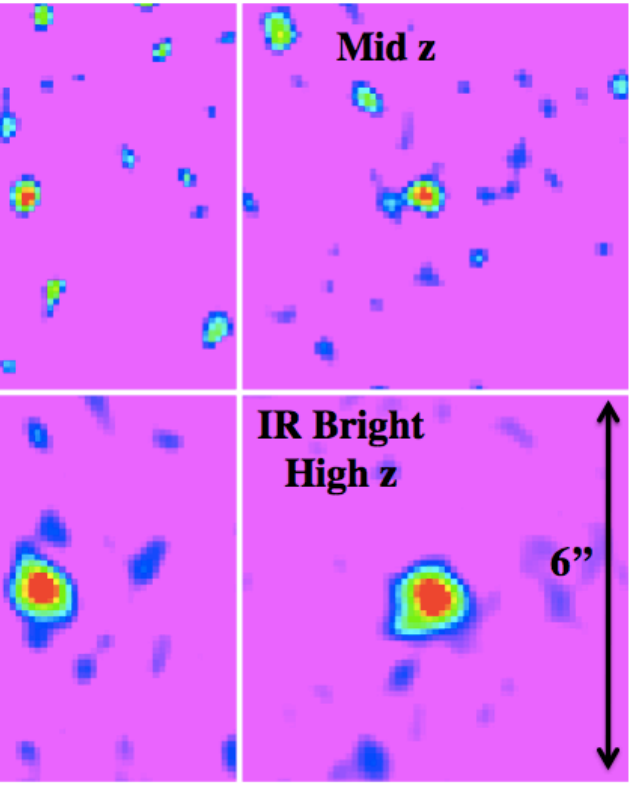
[CII]

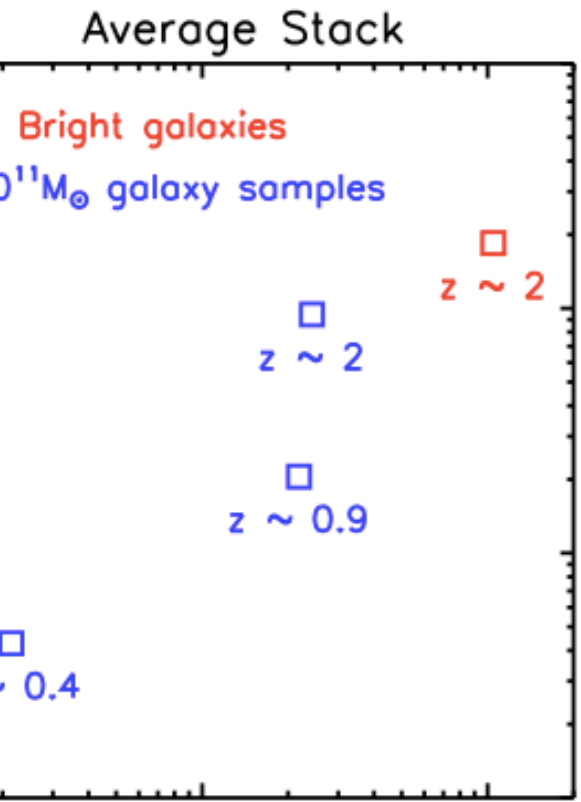


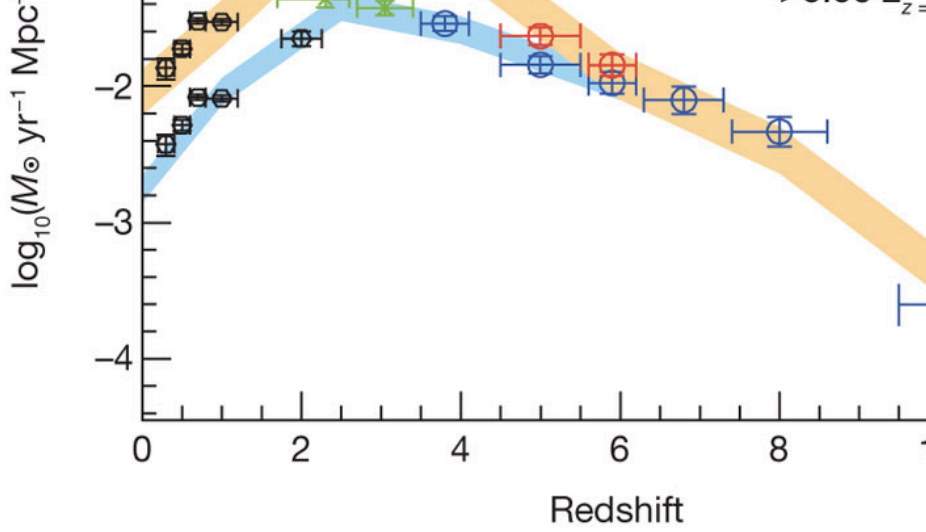
Capak et al. 2015

Brisbi



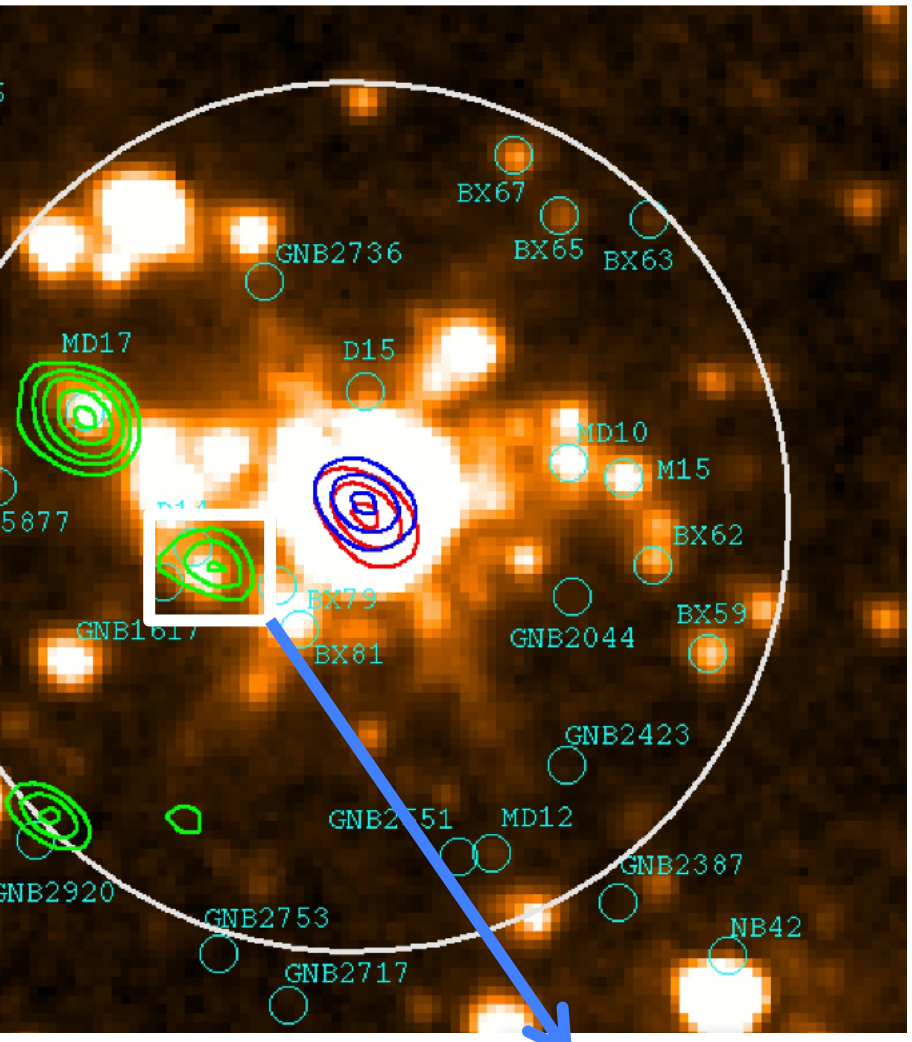


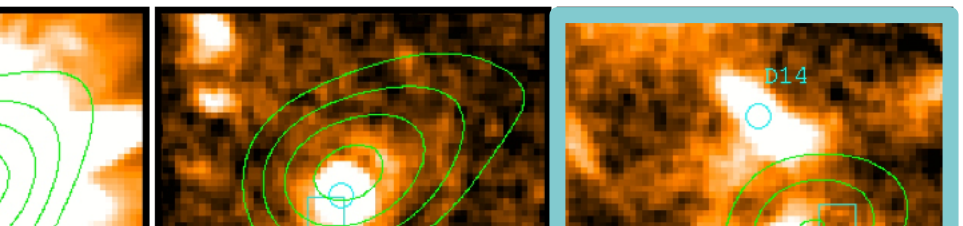


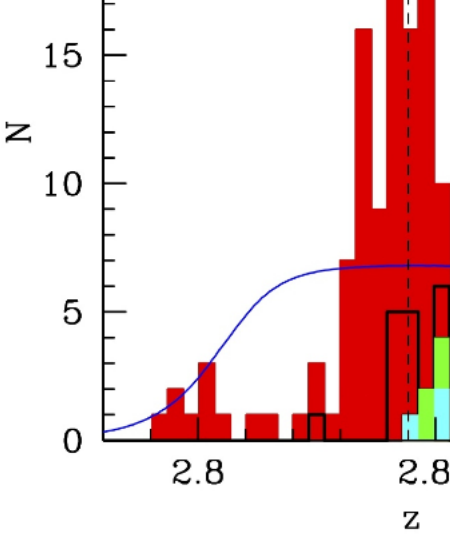


- Molecular gas– critical for understanding the SFRD evolution disk assembly.
- CO Redshift surveys still hard eve with ALMA
- “efficient” ISM mass using dust measurements -- large ALMA bandwidth.

bly well studied Keck field (HS1549+19)
– 283 spec-z members at z=2.85

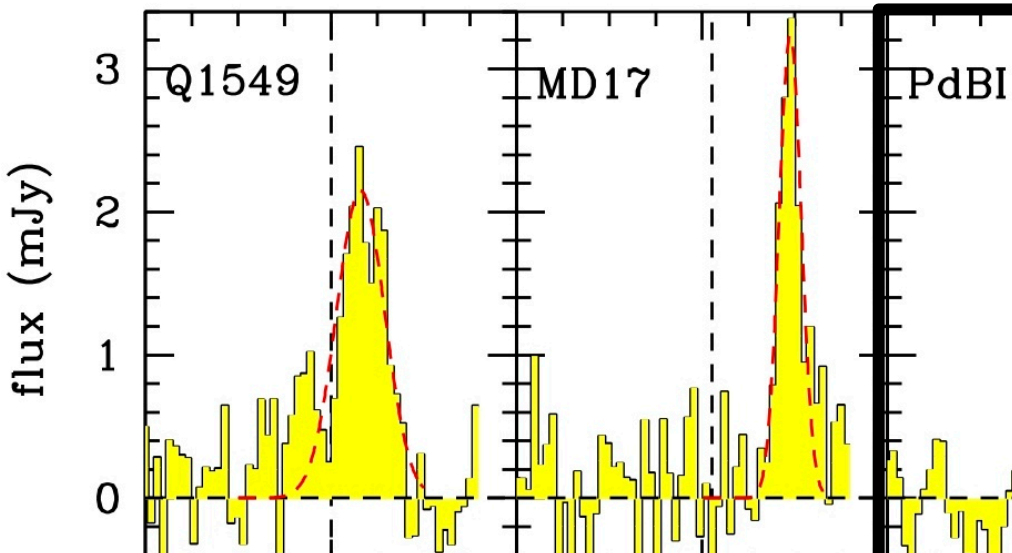


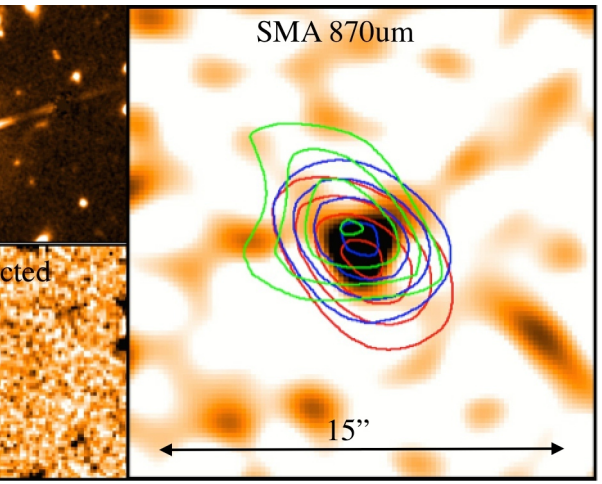


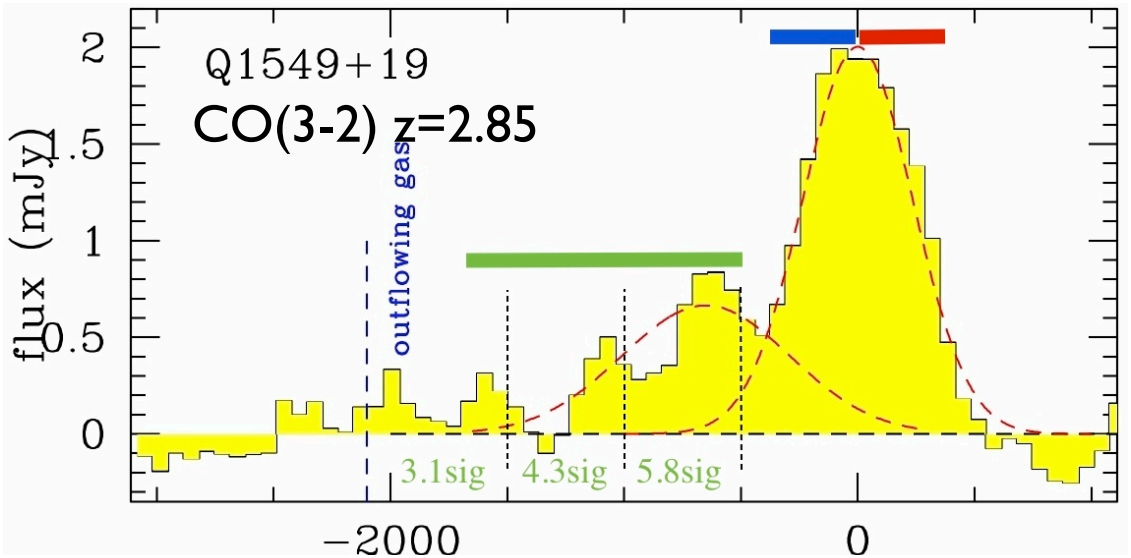


Steidel

3rd brightest CO line in cluste
… *Previously uncatalogued ga*
optically invisible (near-IR det



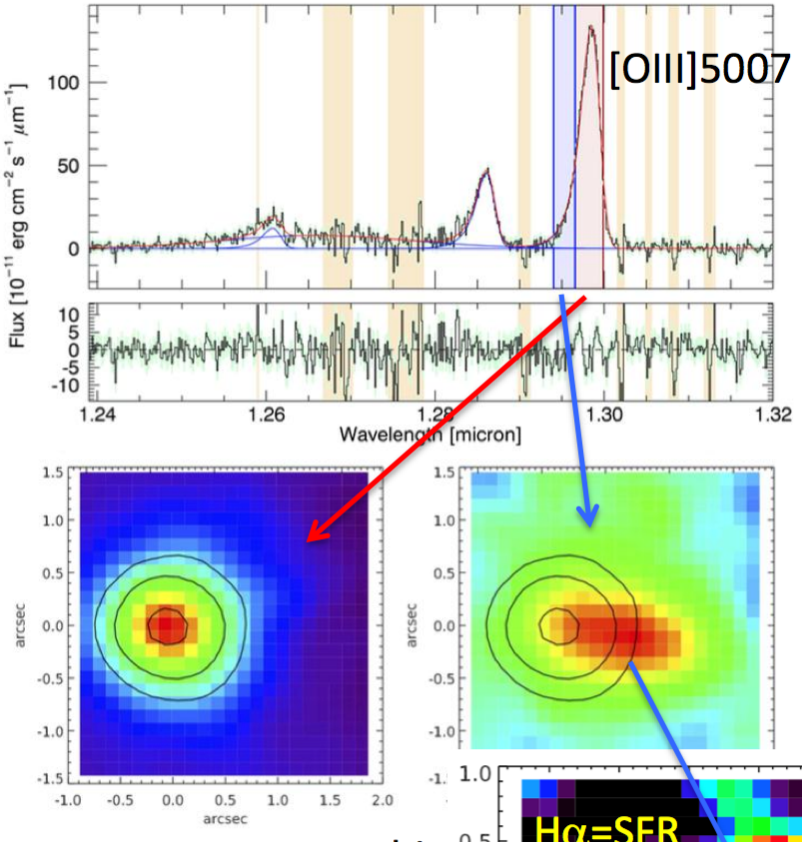




30-50%
being ej

15

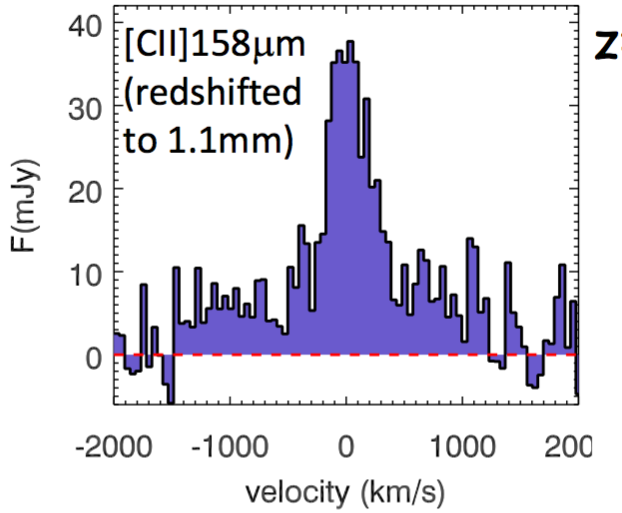
Ionized phase (SINFONI) z~2

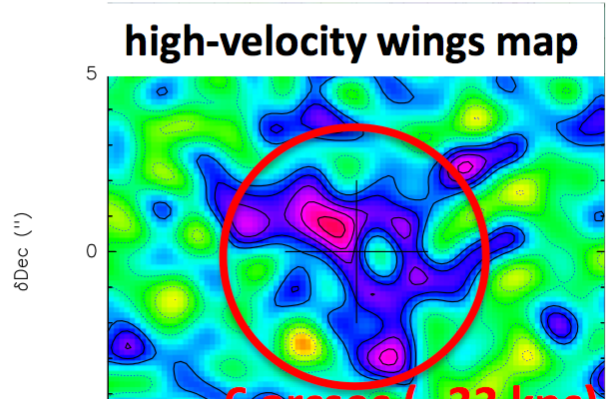


quenching
&

Cresci+14

Cold phase (IRAM, ALMA)





MT, ALMA and JWST will be extremely powerful and
nergistic leading to transformational science in all areas
trophysics.

MT and ALMA will provide extremely high angular reso
ta ~ 10 mas!

e depth of TMT and ALMA will allow us to probe new
rameter space: higher sensitivity → fainter, more distan
jects in a reasonable amount of time.

MT → Near to mid-IR complementary to ALMA

ombination of the distribution of star light, dust and gas
nematics will address a vast range of astrophysics quest


FIN