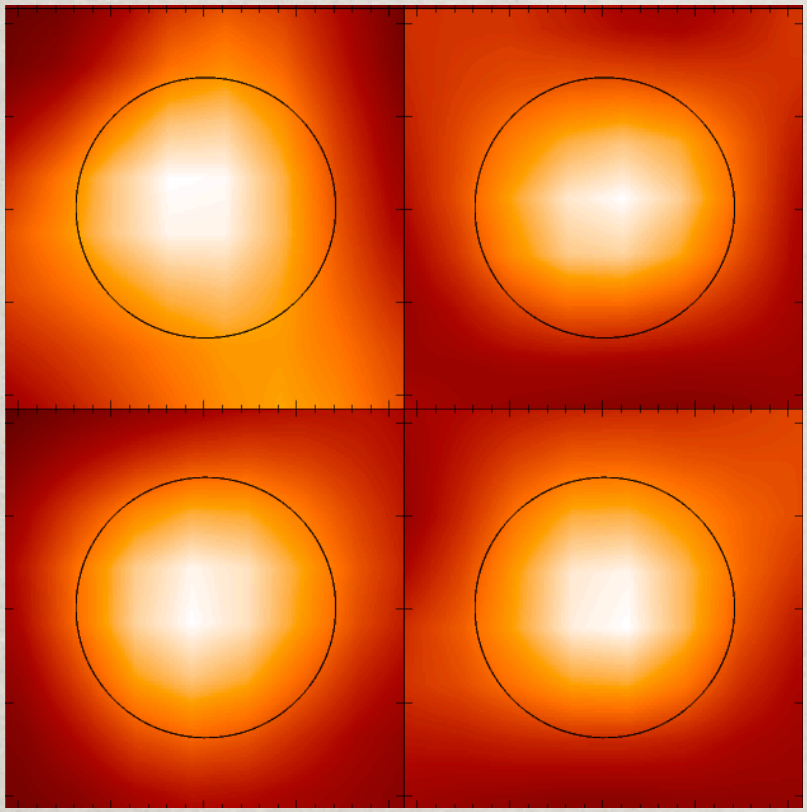
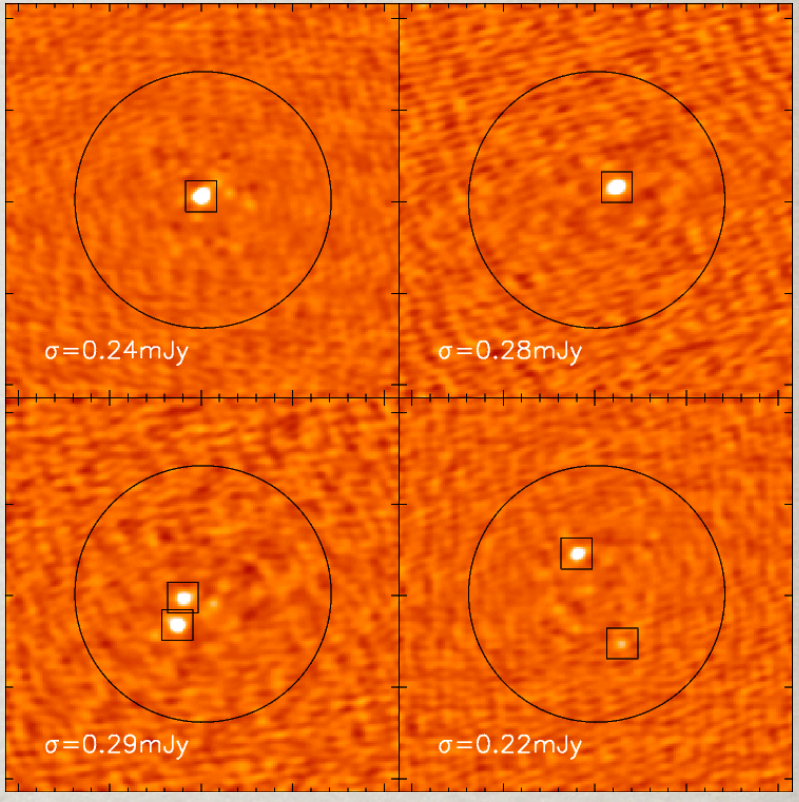
The ALMA LESS survey

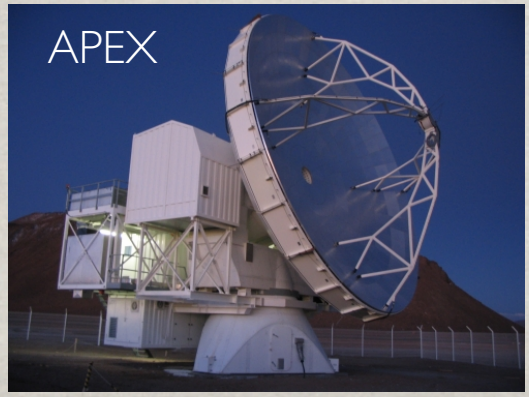
James Simpson (Durham)

pre-ALMA



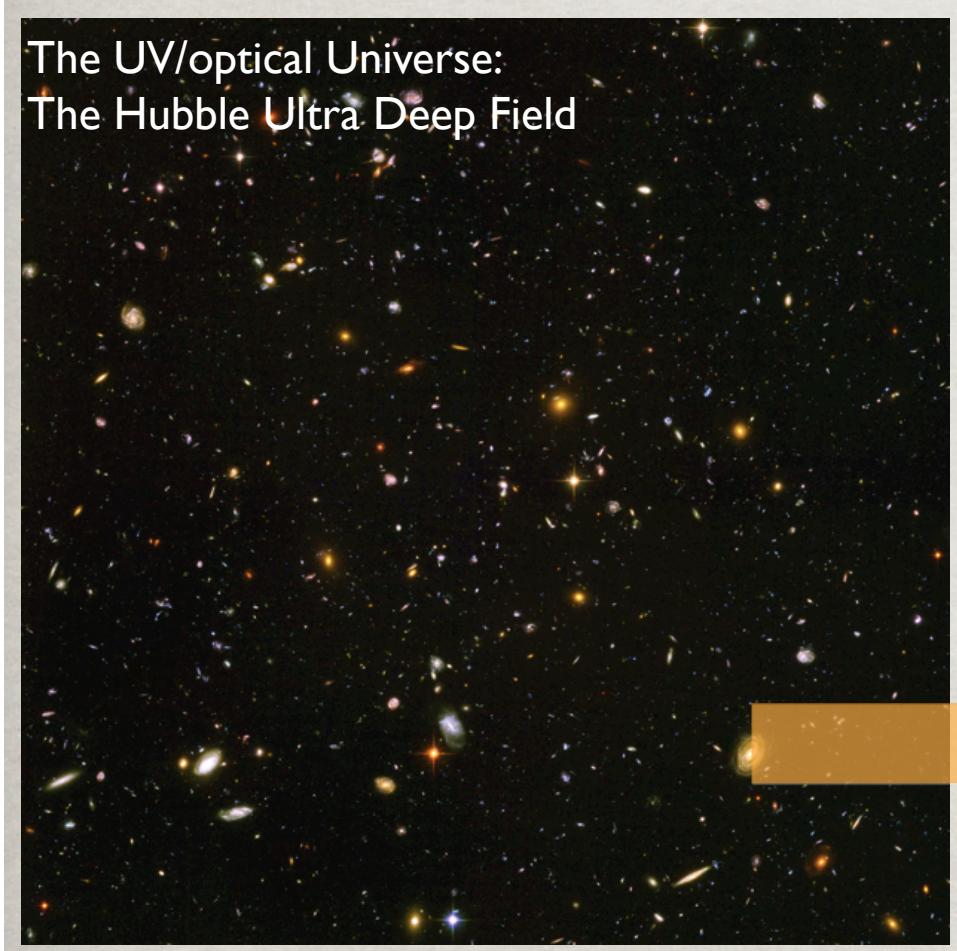
with ALMA

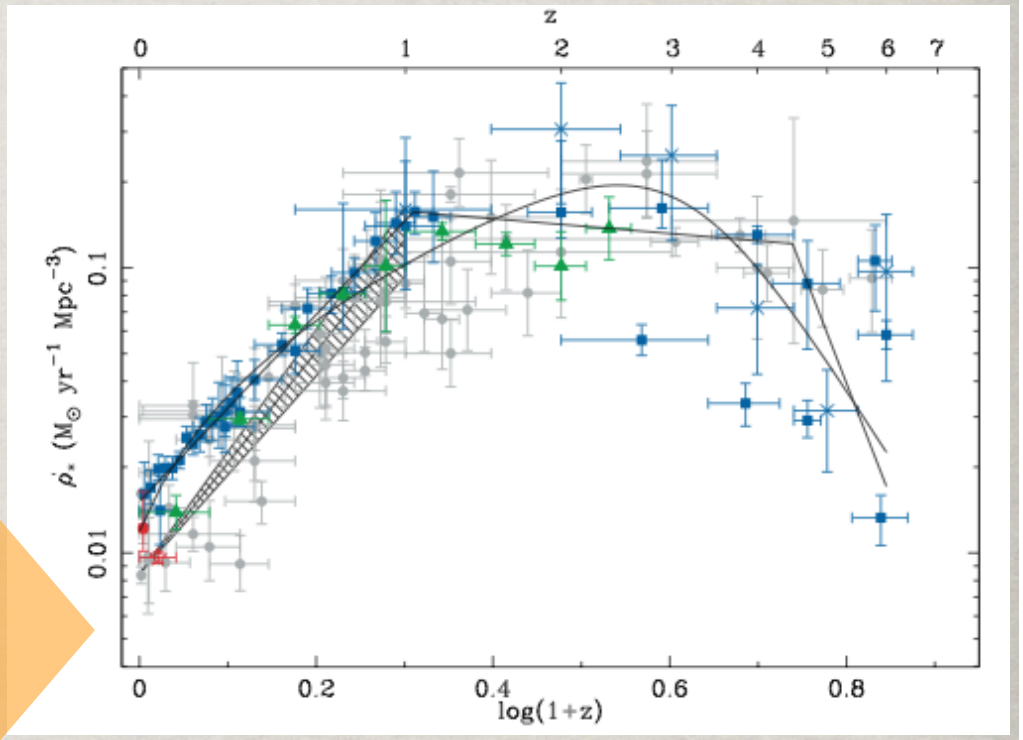




Ian Smail, Fabian Walter, Mark Swinbank, Jackie Hodge, Alex Karim
++ the ALMA-LESS consortium

Epoch of Galaxy Formation





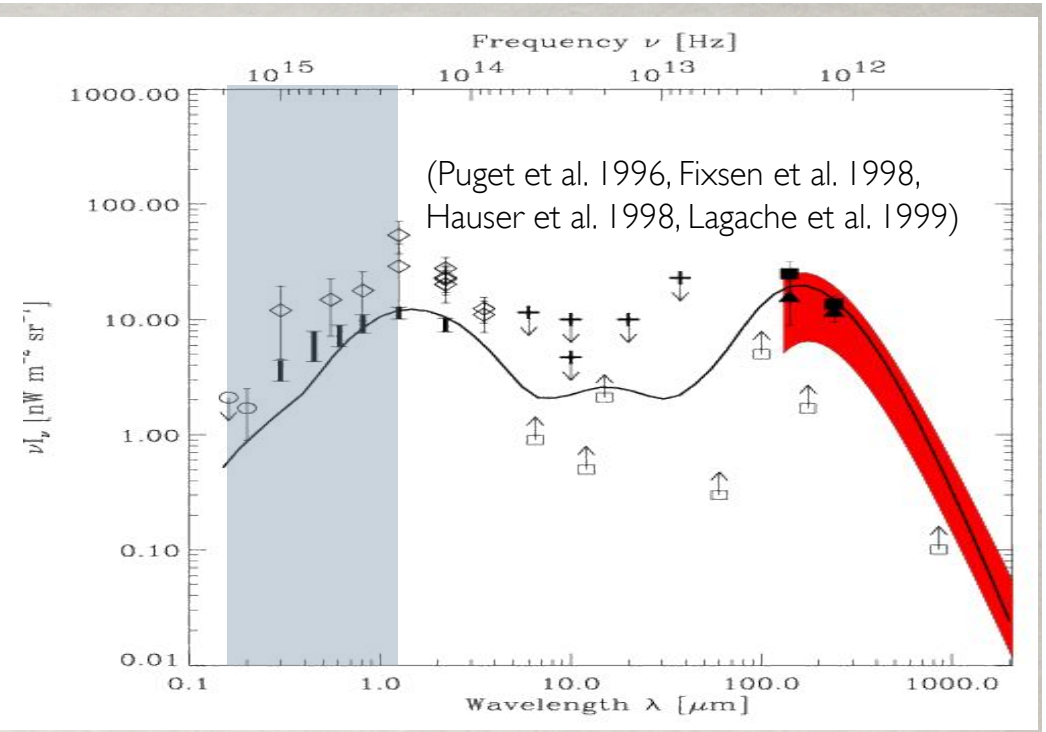
Hopkins & Beacom 2006

- Background in UV and optical is mainly dominated by stars (rather than AGN)

- Luminosity density can be used to track the evolution of the star-formation with redshift to identify the epoch of galaxy formation

•COBE showed that ~50% of the light produced by extra-galactic objects has been reprocessed by dust and re-emitted in the far infrared and sub-mm.

•Far Infrared background = opt/UV --> half of the energy production (from SF or AGN) over history of the Universe arises in highly obscured regions

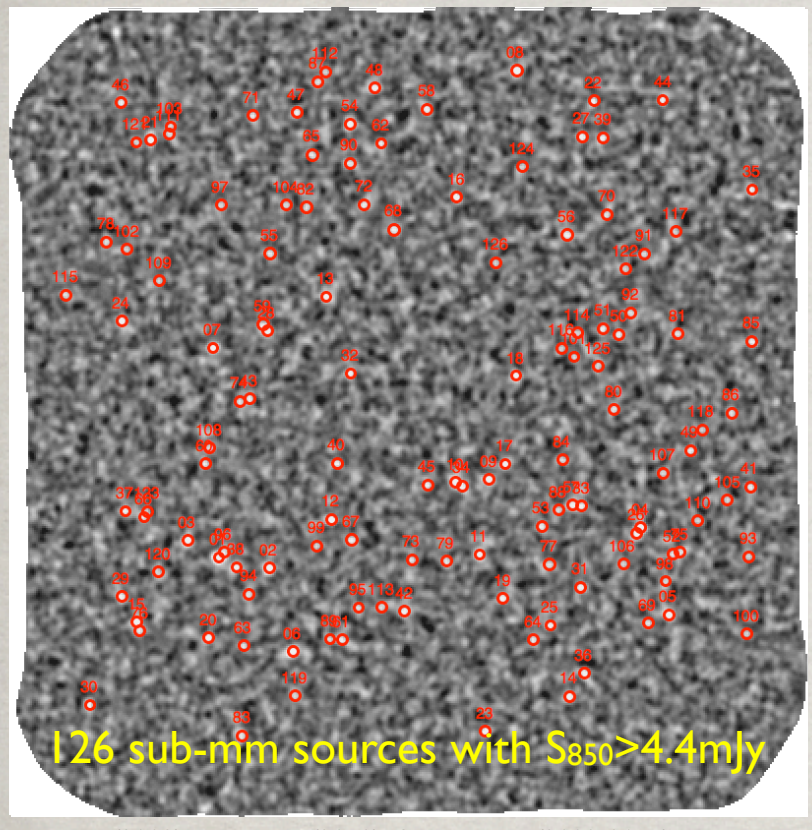


HST - optical

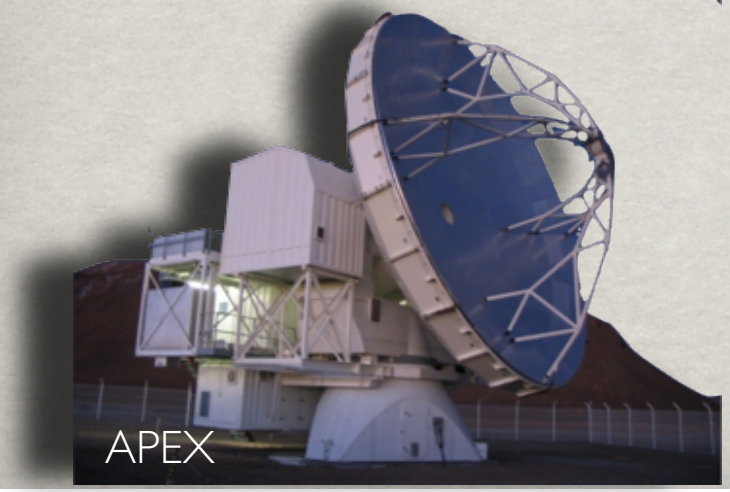
Herschel 250-500μm

- Most luminous FIR gals at z~0 are Ultra Luminous Infrared Galaxies (ULIRGs)
- $L_{FIR}>10^{12}L_o$, inferred SFRs 100's M_o/yr
- >95% Luminosity comes out in FIR (~10-1000um)
- Host <1% of star formation at z=0 - maybe more important at high-z?

LABOCA Extended Chandra Deep Field South Survey (LESS)

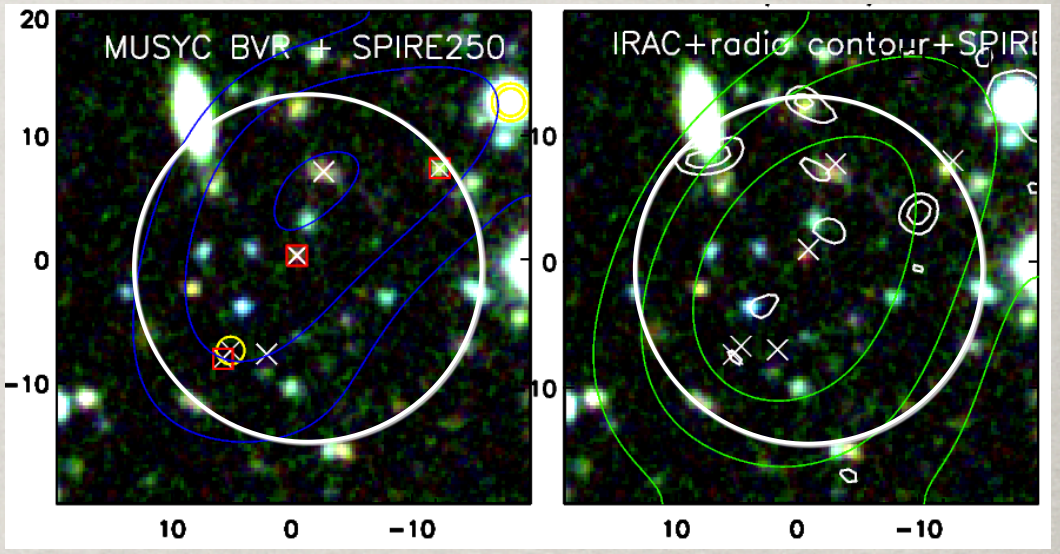


Weiss et al. (2009); Biggs et al. (2010); Coppin et al. (2009, 2011); Dunlop et al. (2010); Greve et al. (2011); Hickox et al. (2011); Wardlow et al. (2011); Chapin et al. (2011); de Breuck et al. (2011); Nagao et al. (2012)



The ECDFS is the prime extra-galactic survey field, with wealth of multi-wavelength data from Chandra X-ray; UV/optical+mid-IR; HSO SPIRE; APEX LABOCA and VLA radio.

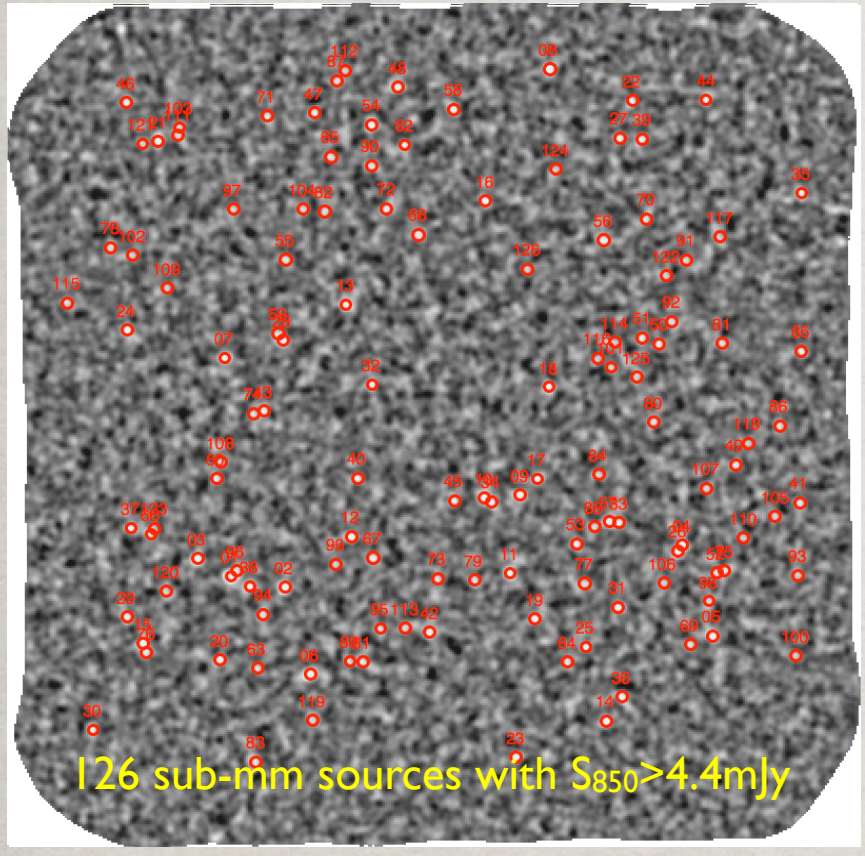
LESS is a contiguous & uniform 870μm survey, reaching σ_{870}=1.2mJy over ~30x30'



λ/D~18" (so lots of possible counterparts for each sub-mm source)

Adding Herschel imaging does not improve situation for IDs since resolution is ~15", 25" and 35" at 250, 350 & 500μm

The ALMA LABOCA Extended Chandra Deep Field South Survey (A-LESS)



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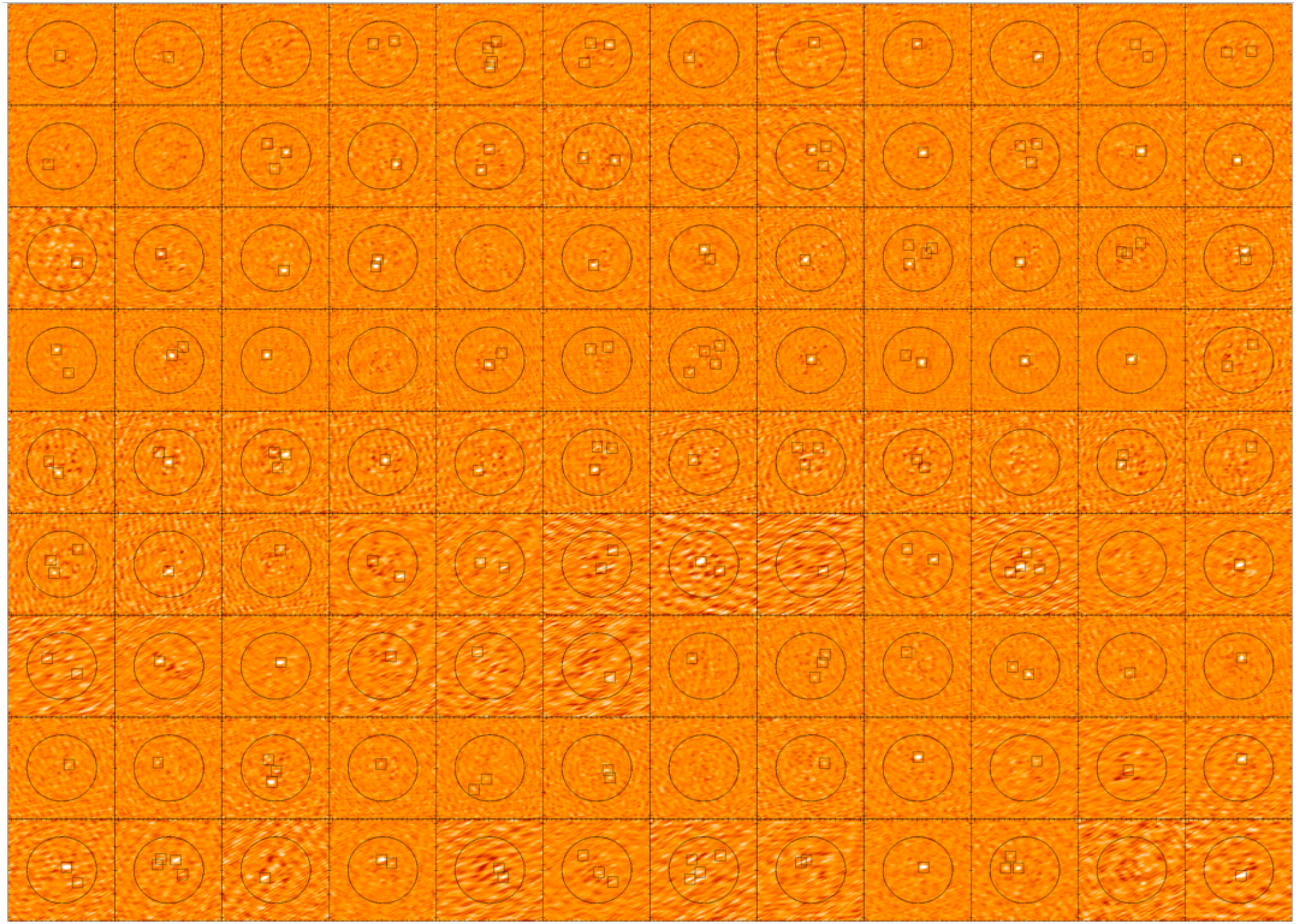
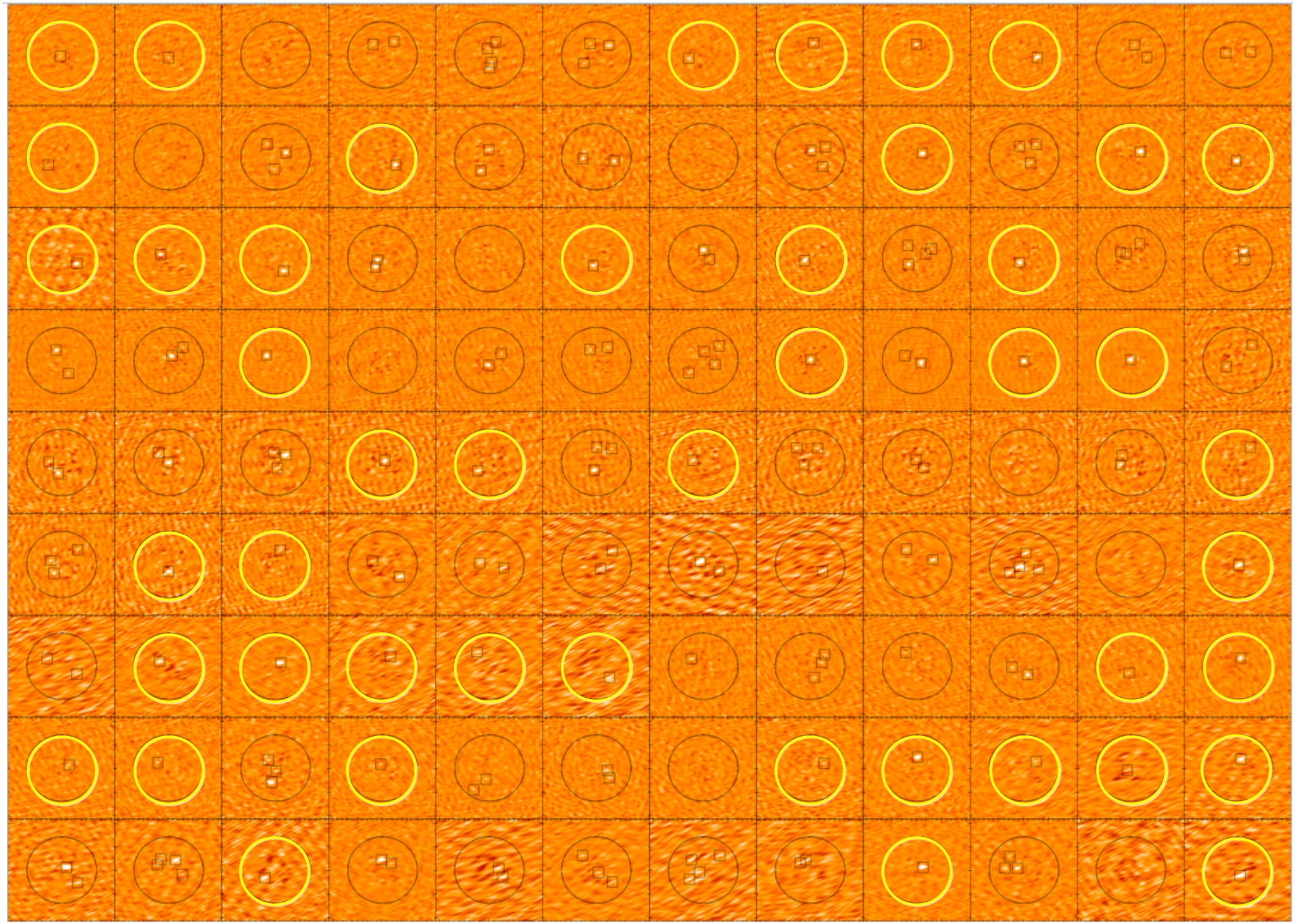
Survey all 126 sub-mm sources in ECDFS at 870um to depth of 0.3mJy in compact configuration.

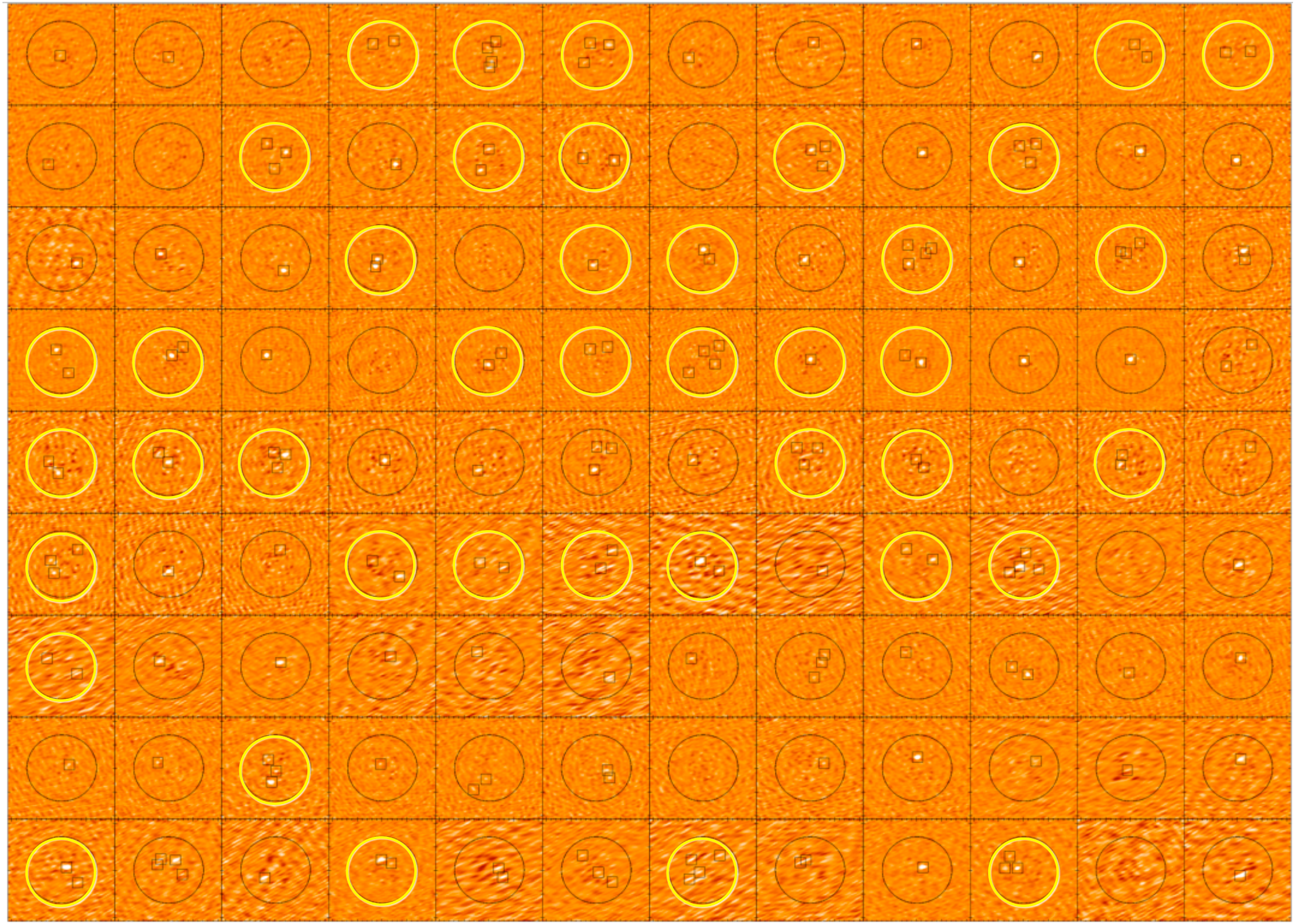
2 mins / source (c.f. 300hours with APEX to 1.2mJy)

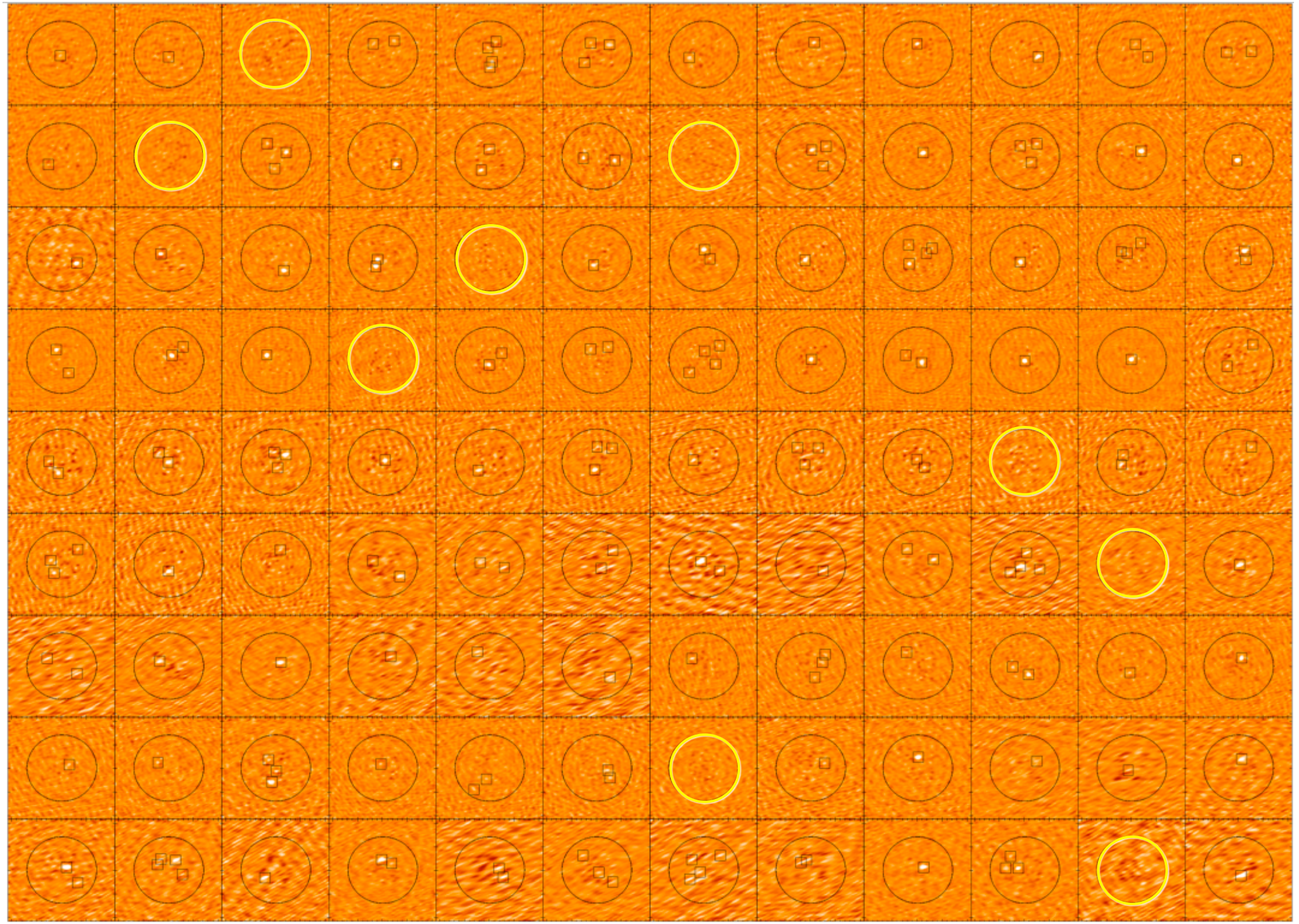
Crucially, at a resolution of 1.4”

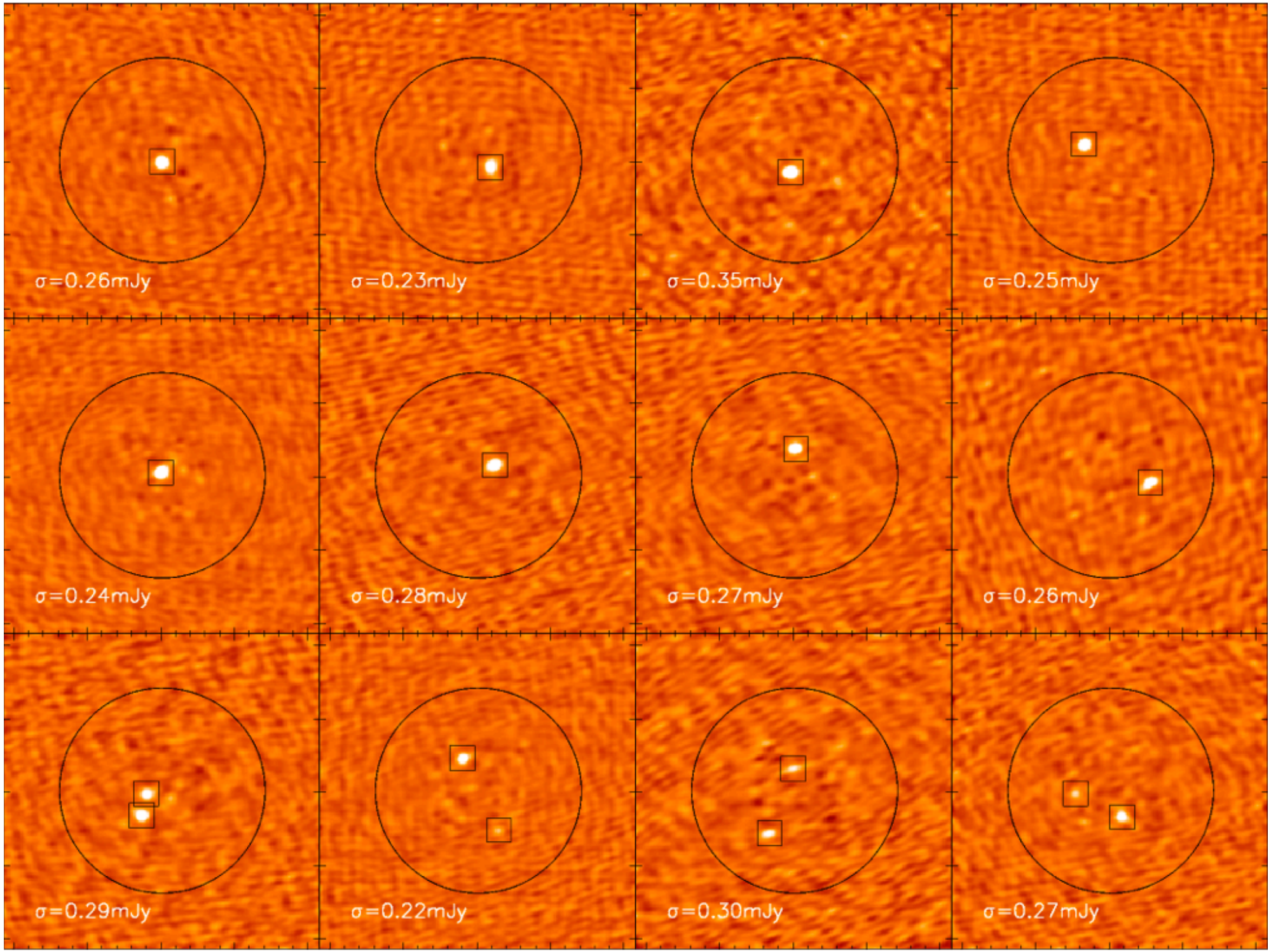
CREDIT: ALMA (ESO/NAOJ/NRAO)/W. Garnier (ALMA)










σ=0.26mJy
σ=0.23mJy
σ=0.35mJy
σ=0.25mJy
σ=0.24mJy
σ=0.28mJy
σ=0.27mJy
σ=0.26mJy
σ=0.29mJy
σ=0.22mJy
σ=0.30mJy
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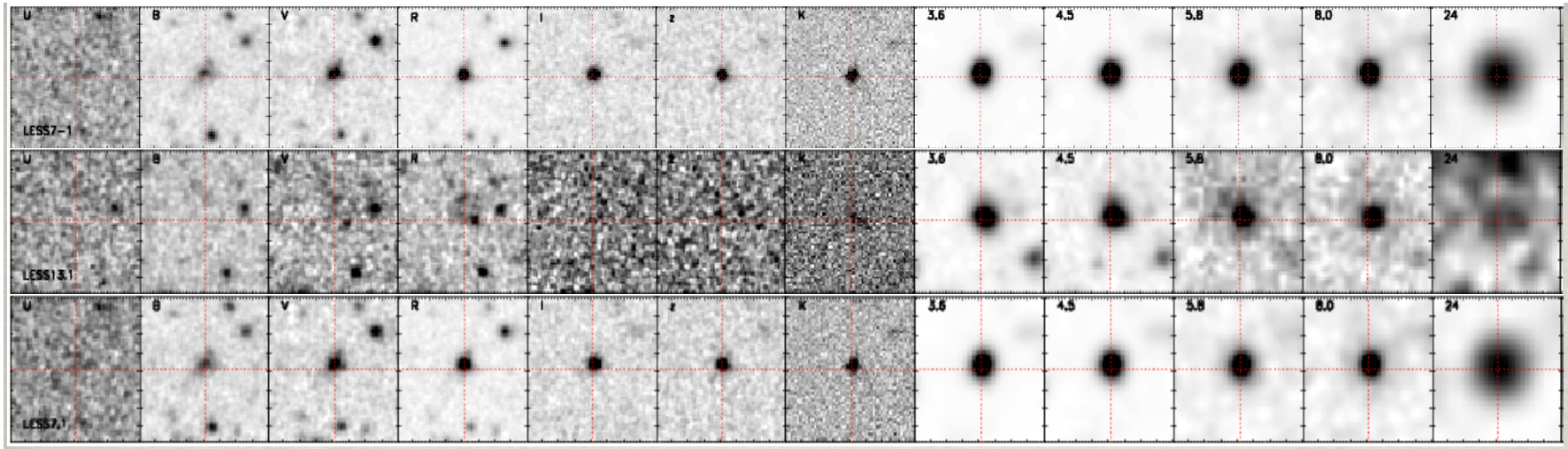
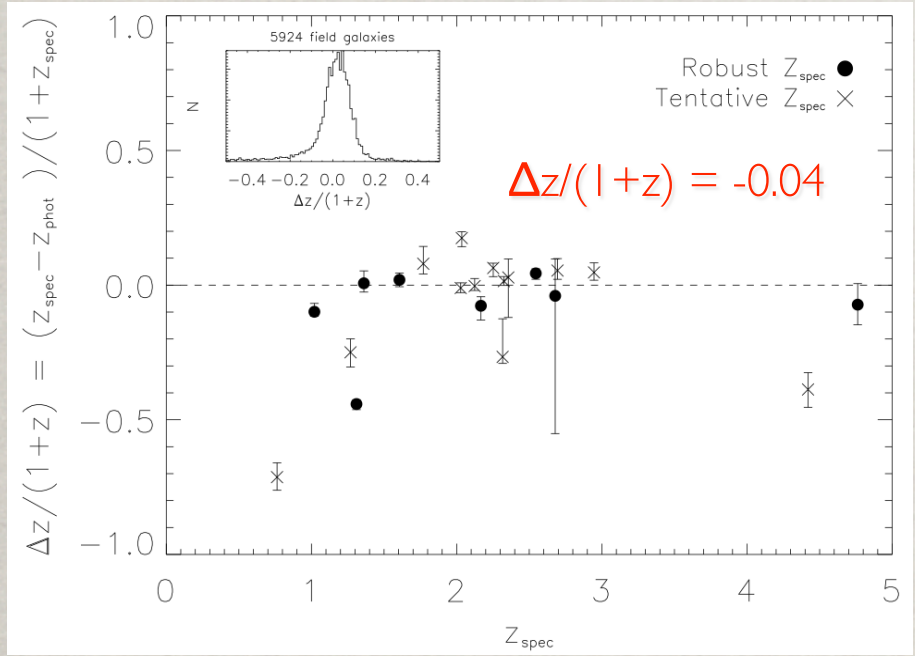
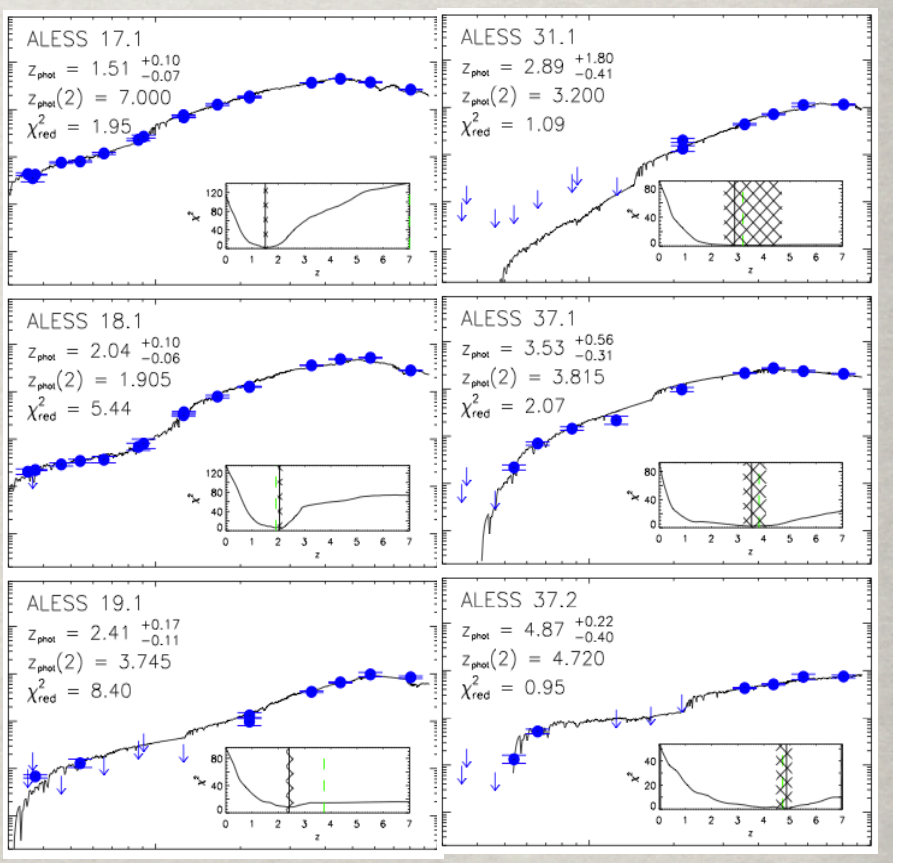


ECDFS deep archival imaging: UBVRIzJHK +IRAC



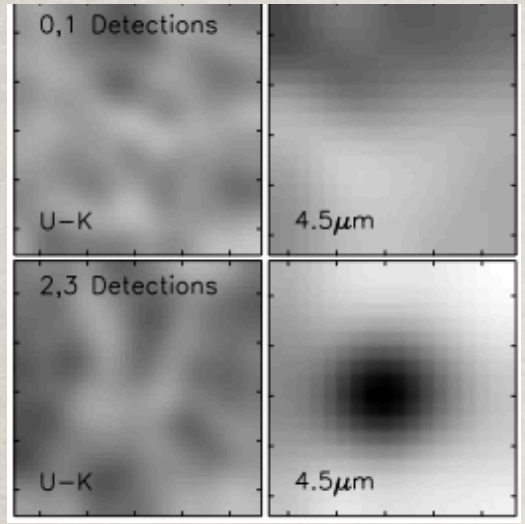


- 96 ALMA SMGs
- Calibrate against 5900 field galaxies in ECDFS
- ~25 SMGs with spec-z's
- Derive photo-z for 77 SMGs with > 3 band photometry

Simpson et al. 2014 ApJ Submitted

BUT:

- 19 SMGs (20% of sample) have 0-1 detections (9) or 2-3 detections (10) in UV/optical/NIR/mid-IR bands
- Real or just S/N effects in 870um catalog?



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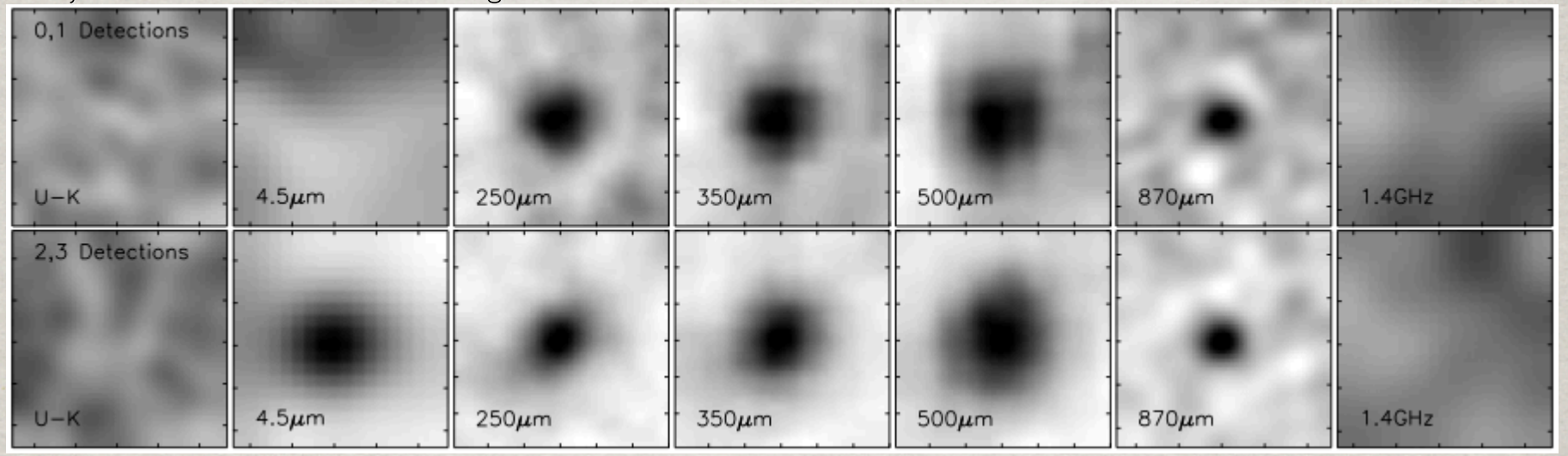
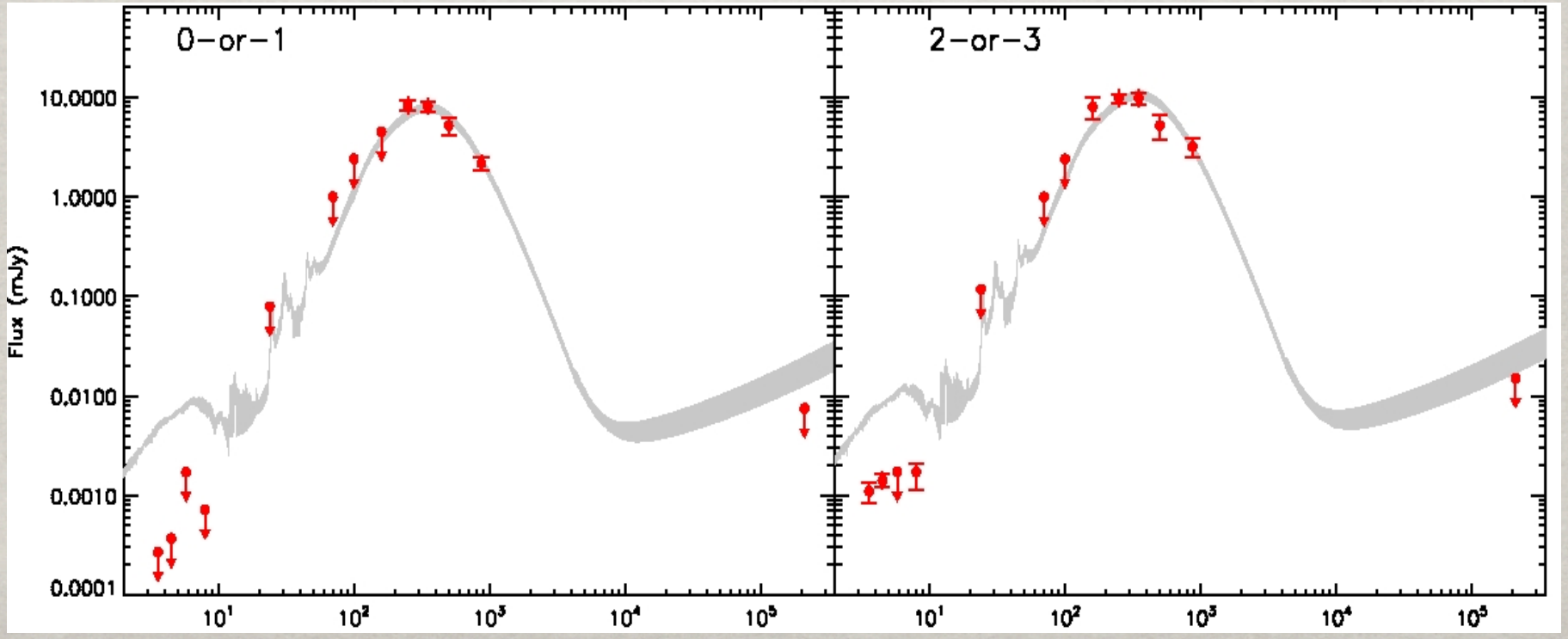
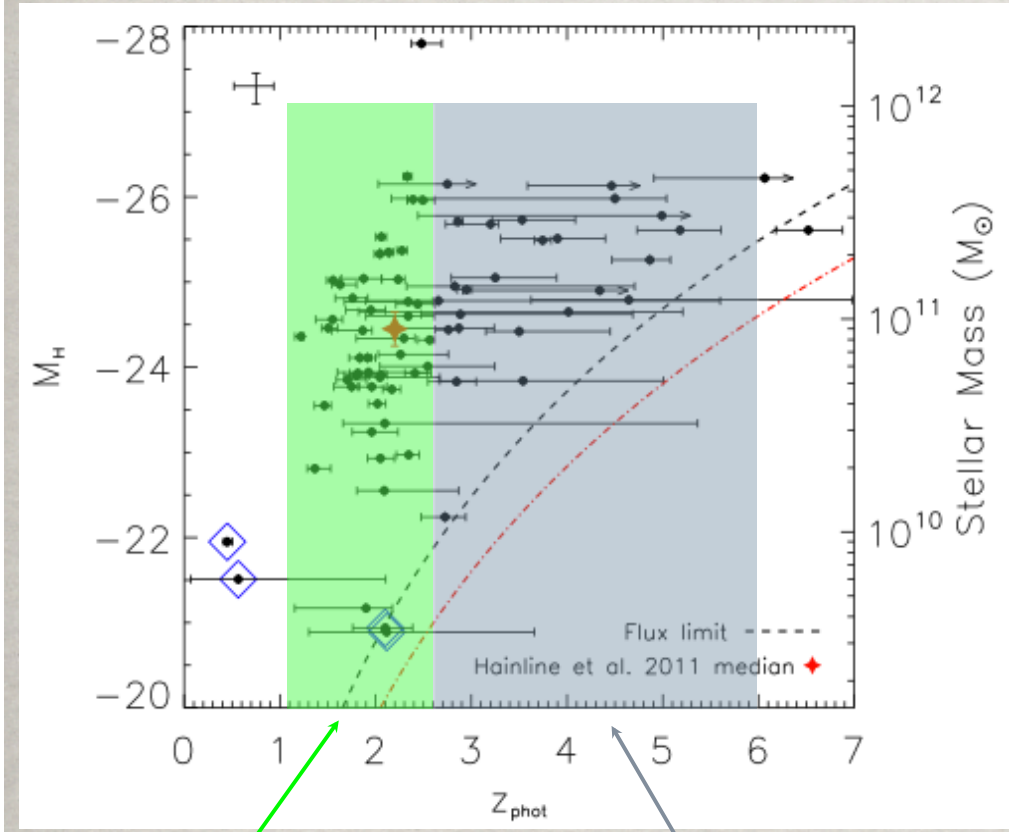




Magnitude distribution and stellar mass



Assume to z=2.5 we have "correct" M_H distribution

MC to derive underlying distribution at z>2.5

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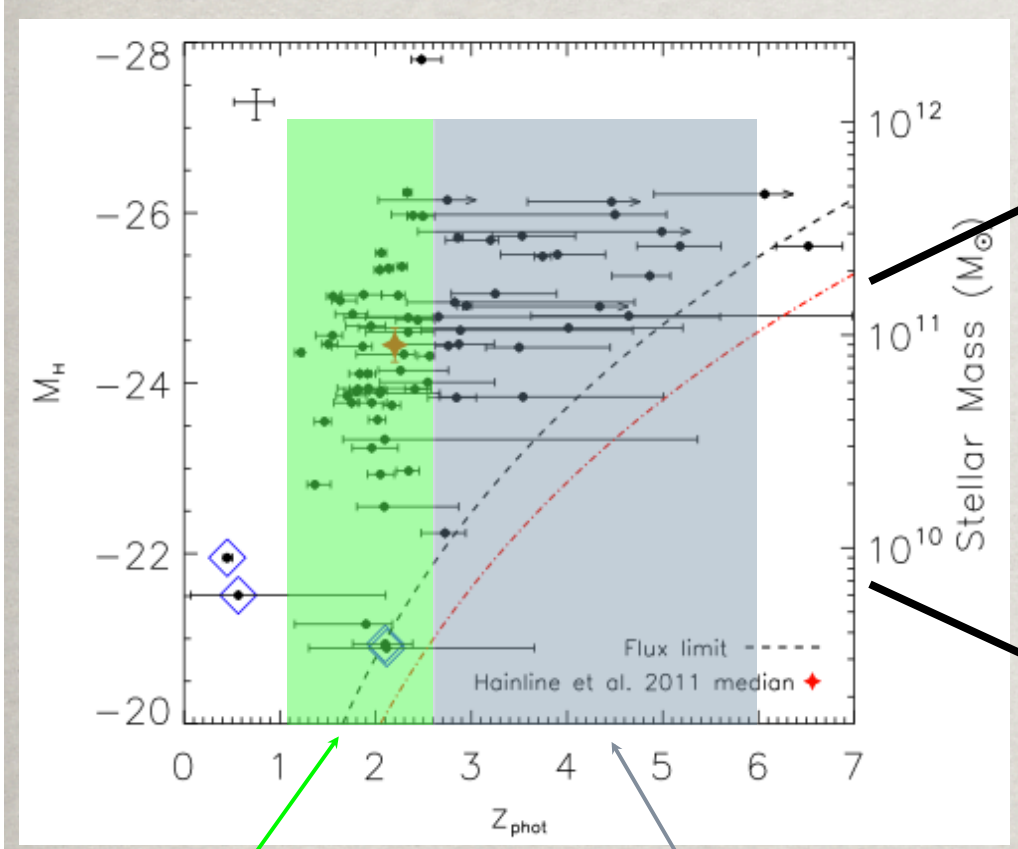

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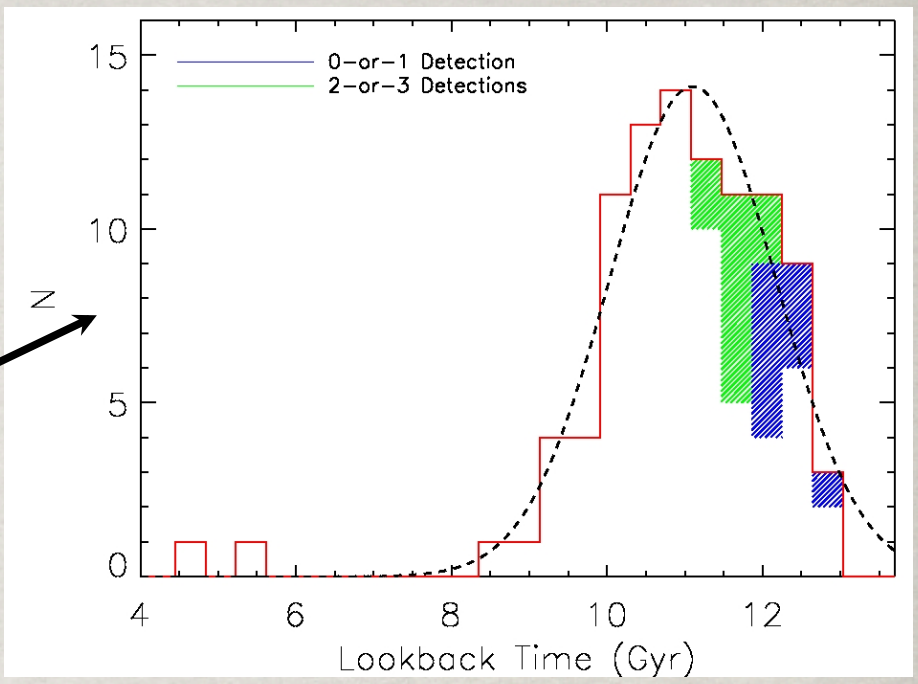
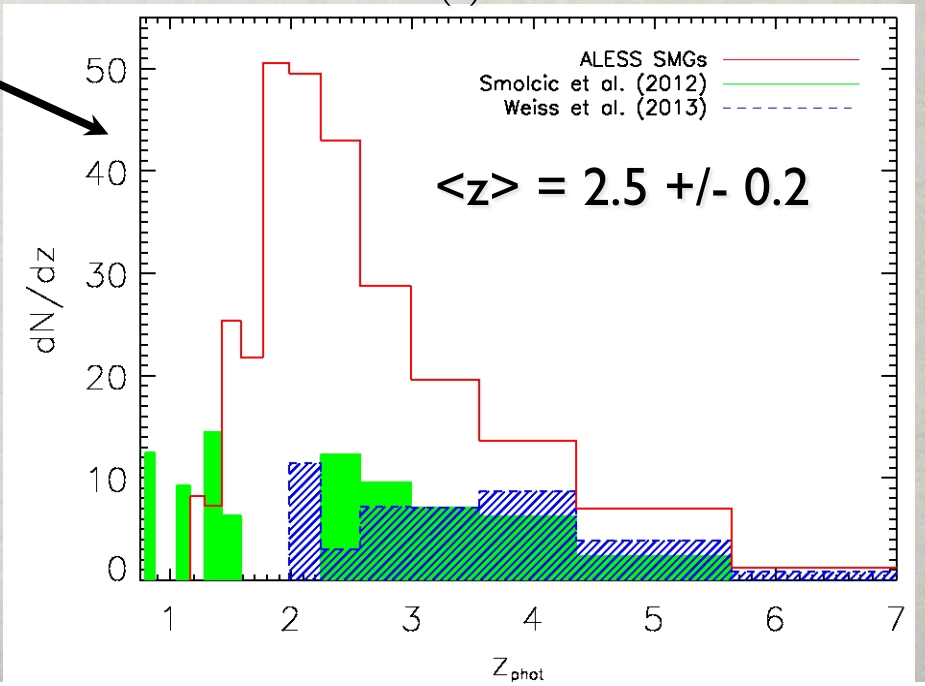
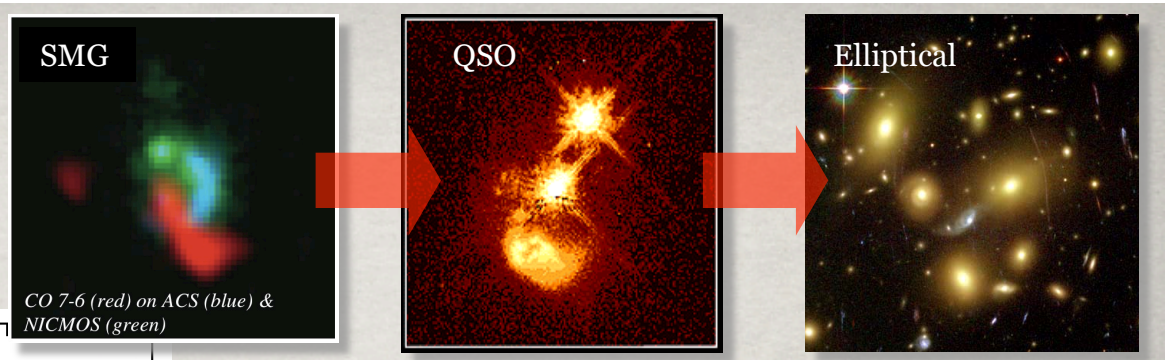
N(t) for ALESS SMGs

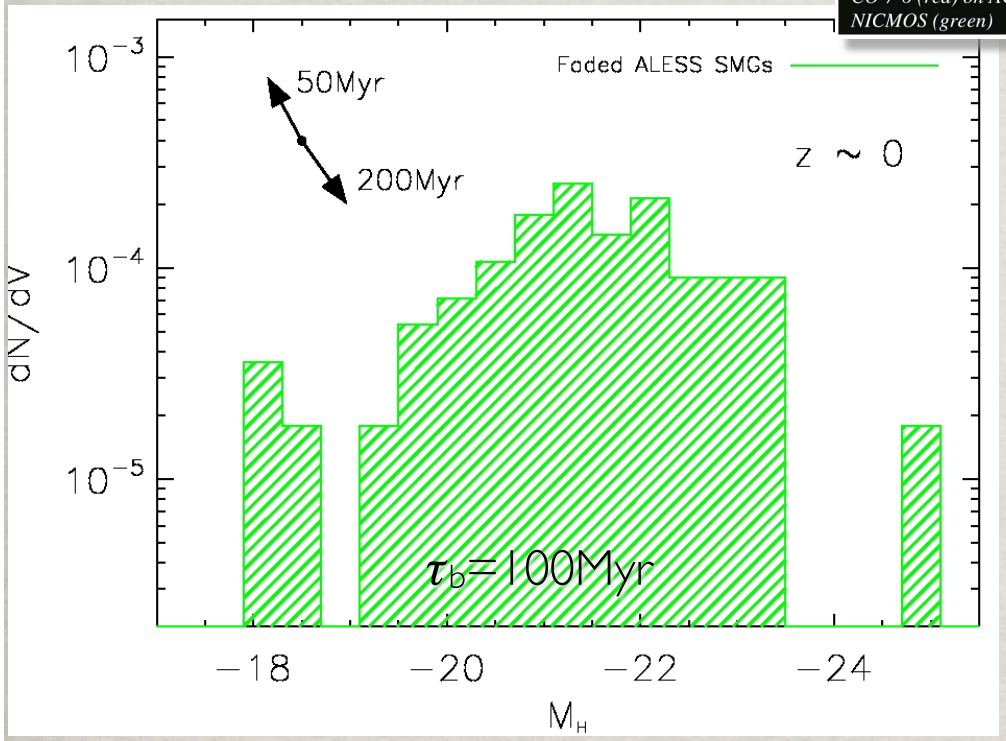


N(z) for ALESS SMGs



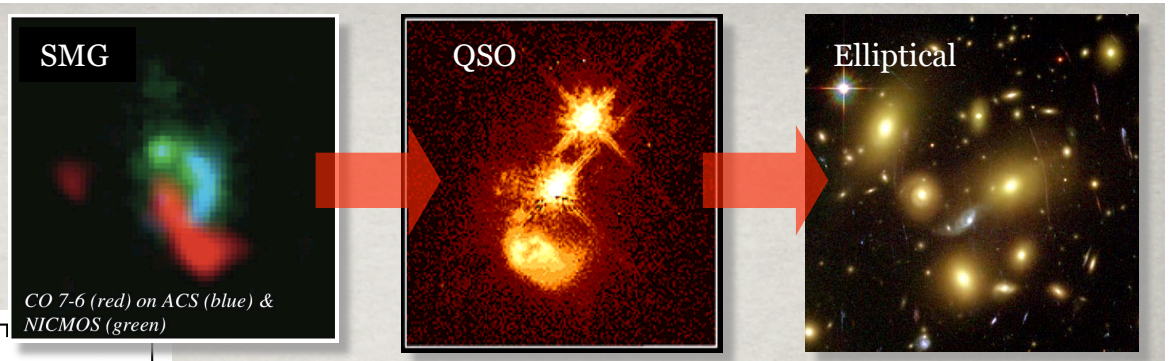
SMG Evolution to z=0

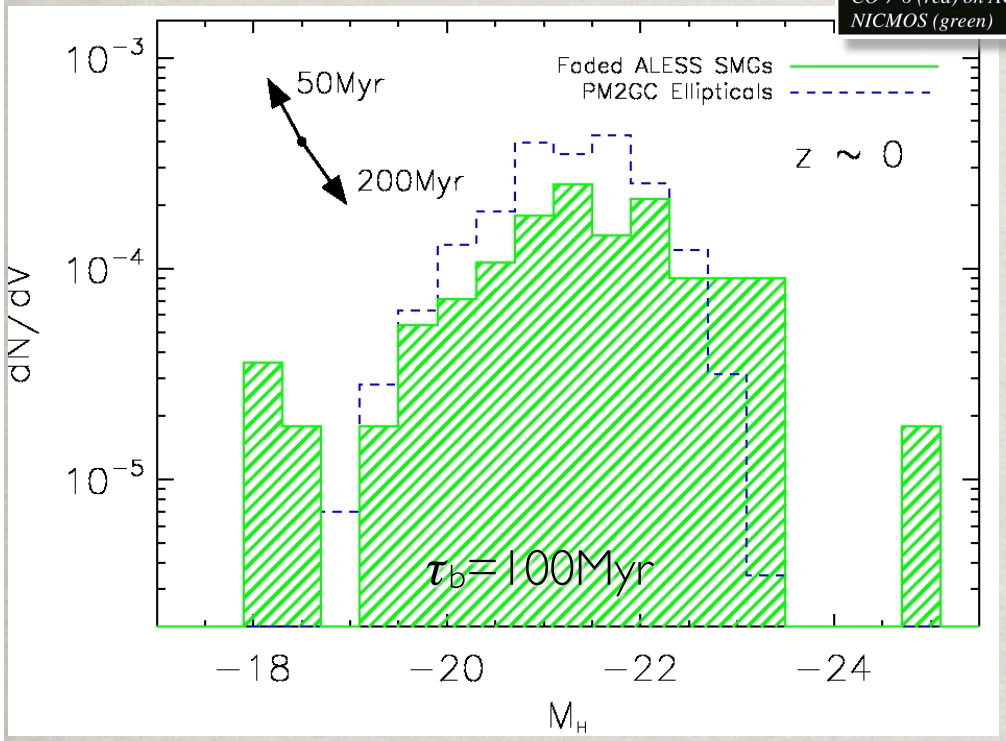




Take N(z); SFR; average lifetime and H-band fading (assume single burst) and calculate the space density of descendants at z=0

SMG Evolution to z=0

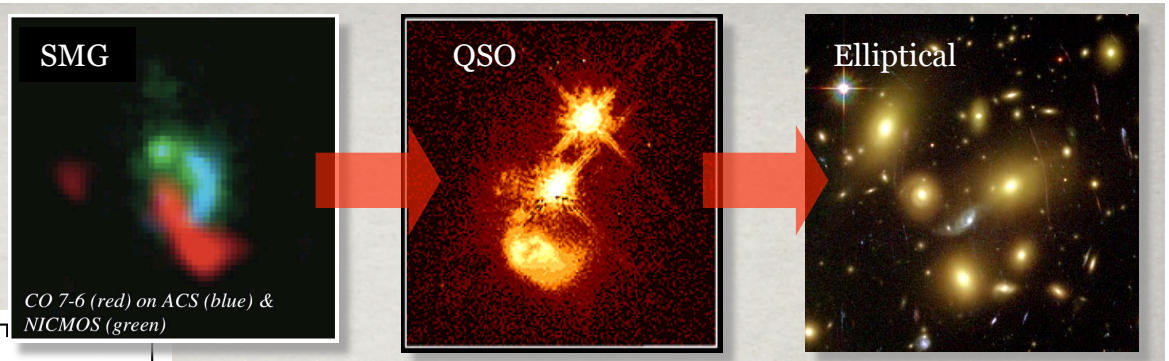


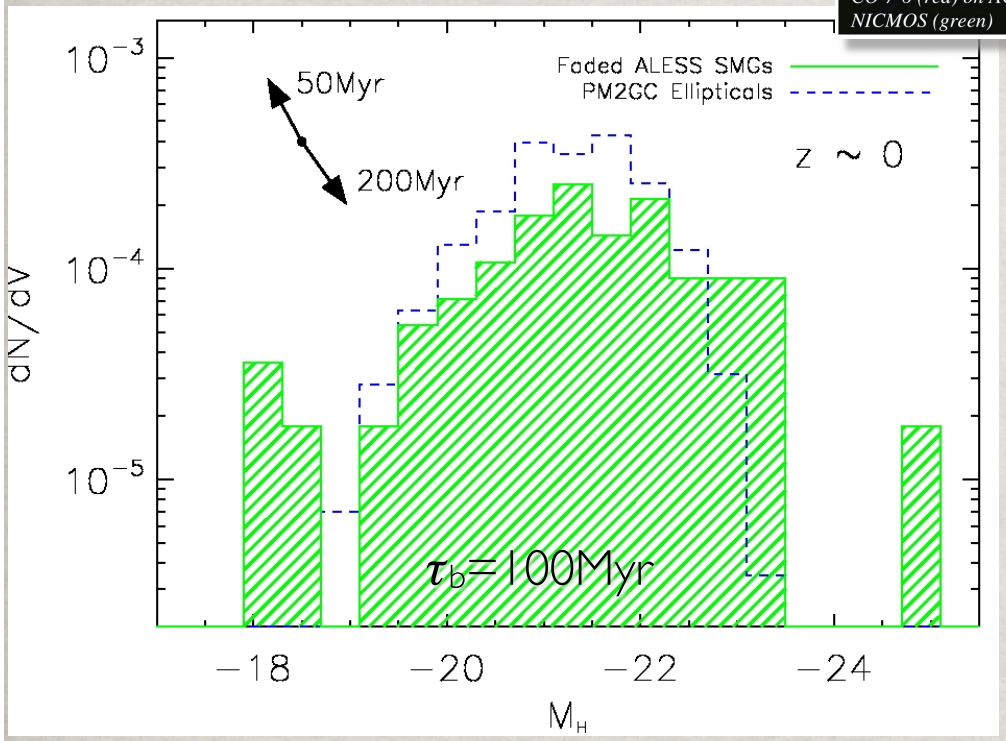


Take N(z); SFR; average lifetime and H-band fading (assume single burst) and calculate the space density of descendants at z=0

If the burst has a ~100Myr duration (compatible with the gas depletion timescales from $M_{H2}/SFR \sim 4\times10^{10} M_o / 400 M_o/yr$) and they only go through one burst then the space density and mass weighted ages of the faded SMG descendents are compatible with the majority of bright Elliptical galaxies at z=0.

SMG Evolution to z=0





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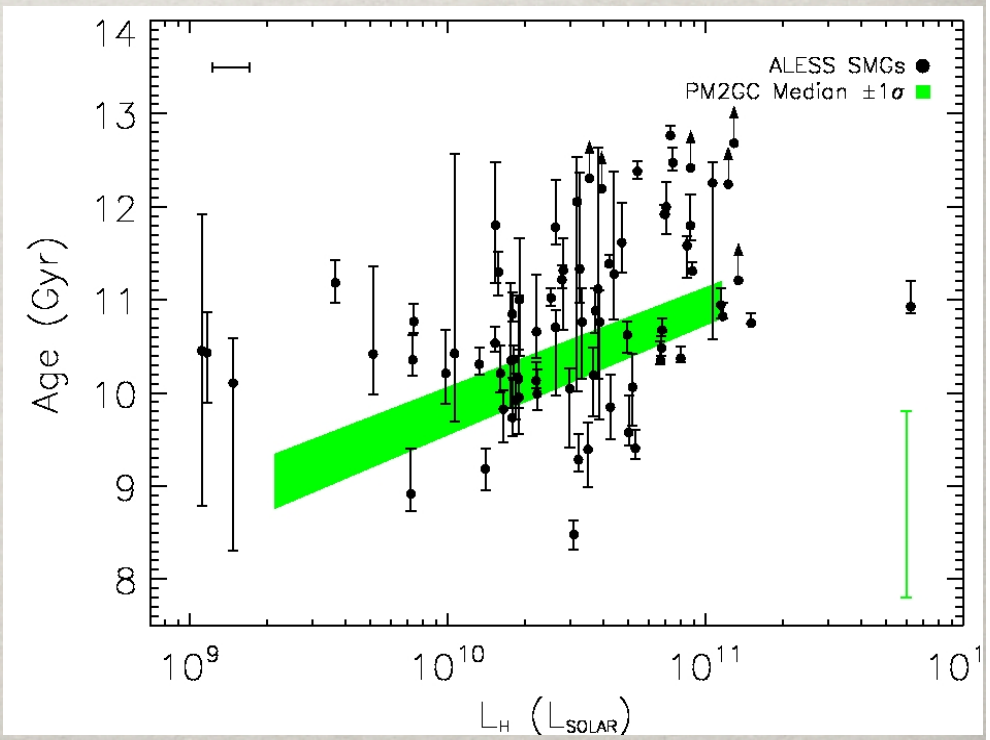

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Conclusions

ALESS: 345GHz continuum mapping of 126 SMGs in ECDFS has produced unbiased sample of 99 robust SMG

~1.4" resolution maps yield a high detection rate: ~50% single IDs; 30% multiple IDs; 20% blank maps. 1 SMG is resolved at 1.4" (12kpc) resolution.

Redshift distribution suggests < z > =2.5+/-0.2, with a significant (but not dominant) tail to z~5.

Fitting the rest-frame FIR SEDs, the bright SMGs account for ~2% of the cosmic SFR-density at z~2. Integrating to 1mJy, this rises to ~20%

Accounting for the fading, the SMG descendent space density and magnitude distribution is consistent with a volume limited sample of morphologically classified ellipticals.

7 Papers accepted and 6 in prep on Multiplicity, Number counts, N(z), FIR-properties, AGN fraction, FIR-radio correlation, [CII] line emission and more