Distant Galaxy Clusters Uncovered by Herschel & Planck

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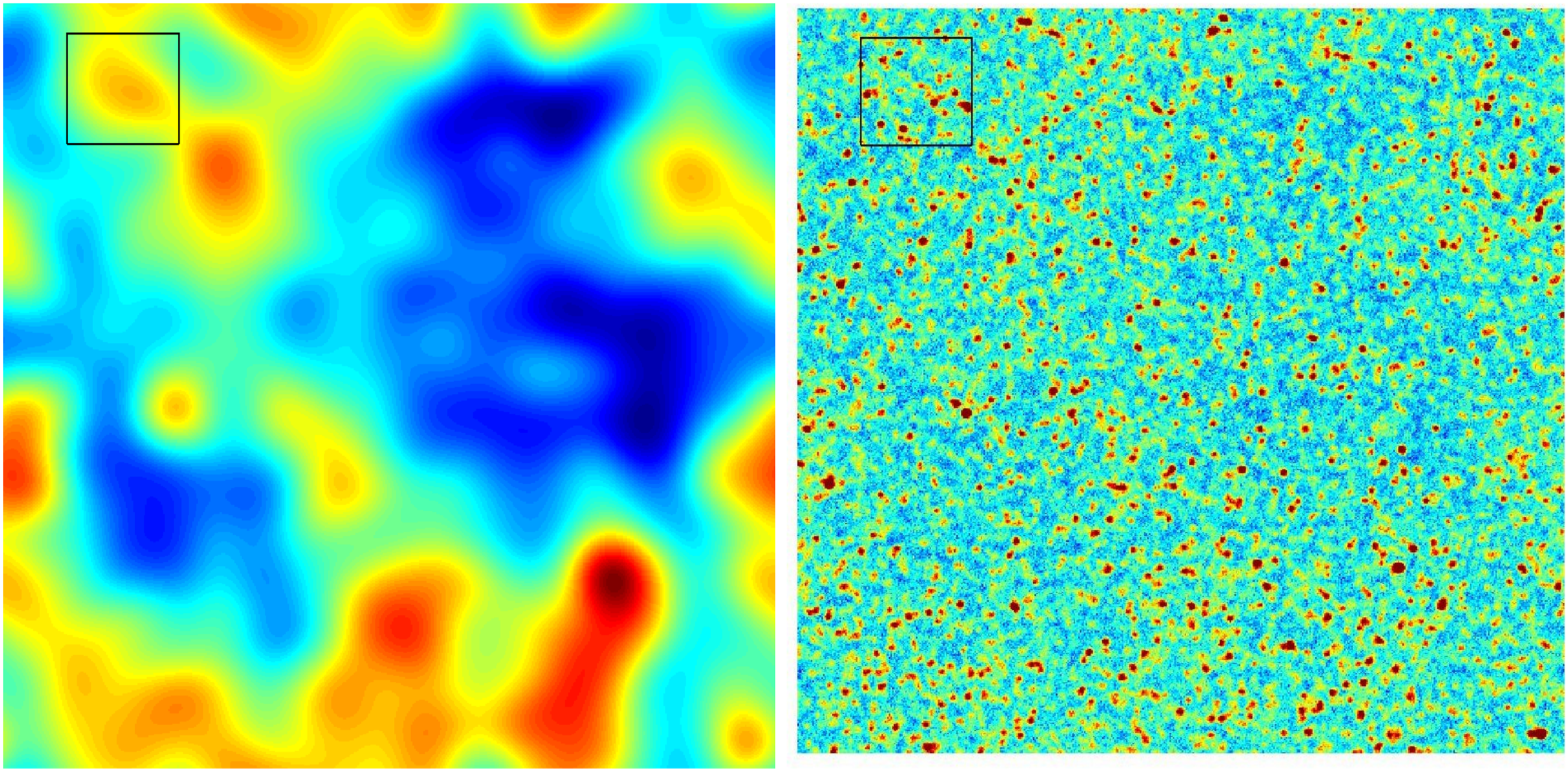
The HerMES & H-ATLAS Collaborations

Planck and High Redshift Clusters

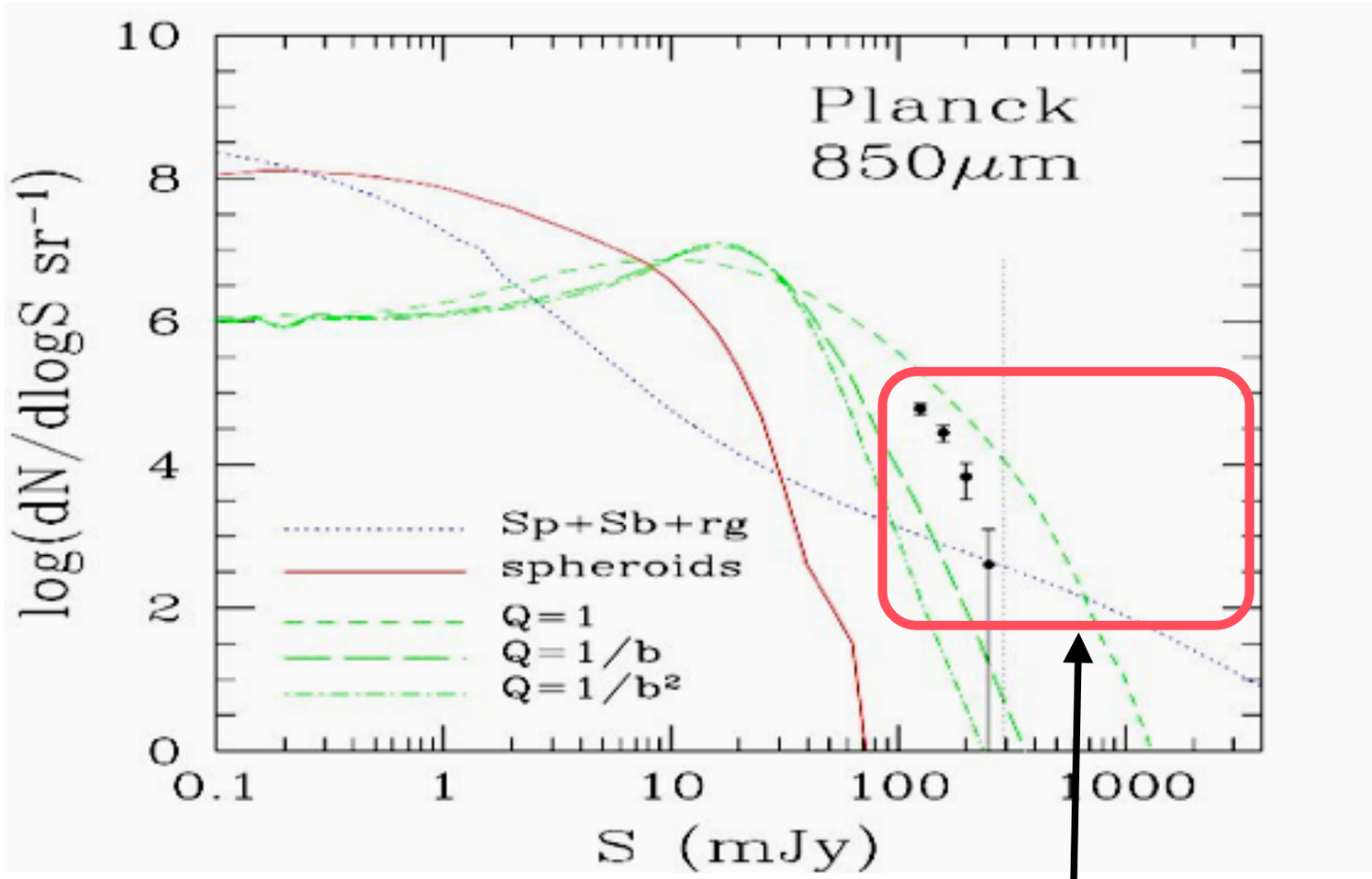


350 μm Sky: Planck & Herschel

- Simulation by Gonzales-Nuevo of 1sq deg region including protocluster (top left) motivated by Granato et al (2004) dusty protocluster models.

Planck & Herschel Surveys

- Negrello et al. 2005 predict 100 - 10000 clumps per steradian detectable by Planck and Herschel
- Would detect appreciable numbers of these objects in HerMES (110 + 270 sq. deg.) and H-ATLAS (570 sq. deg.) surveys
- Working with 'followup' data to ERCSC that already exists



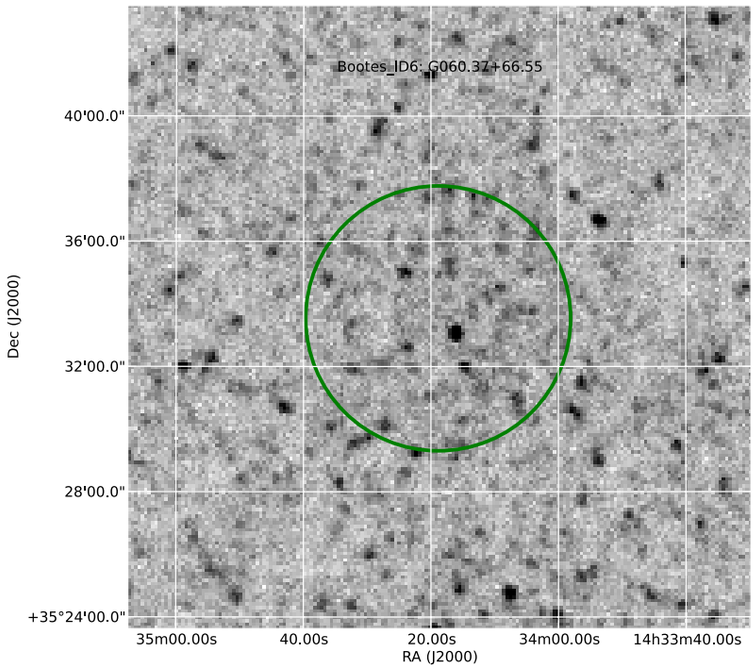
Fluxes and densities accessible to Herschel Key Programme Surveys

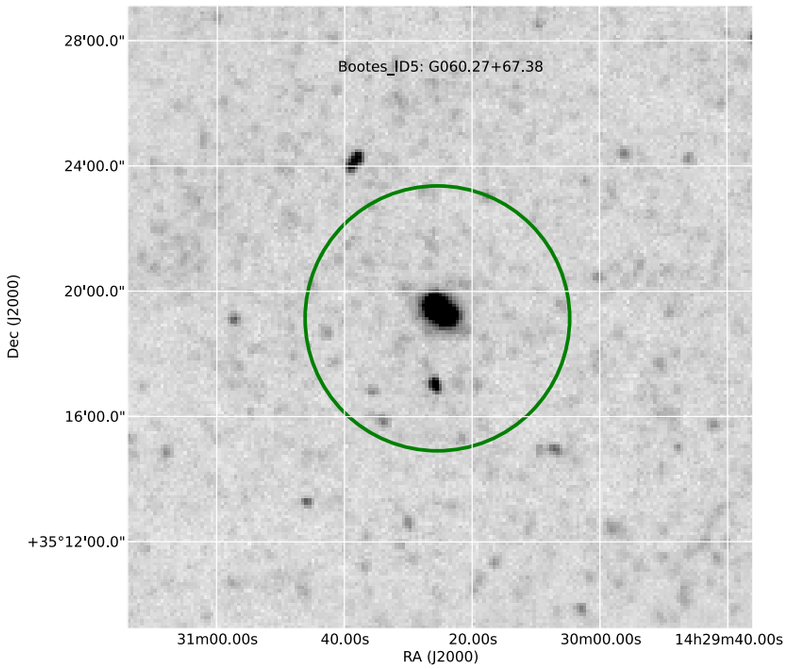
Planck ERCSC Sources in HerMES

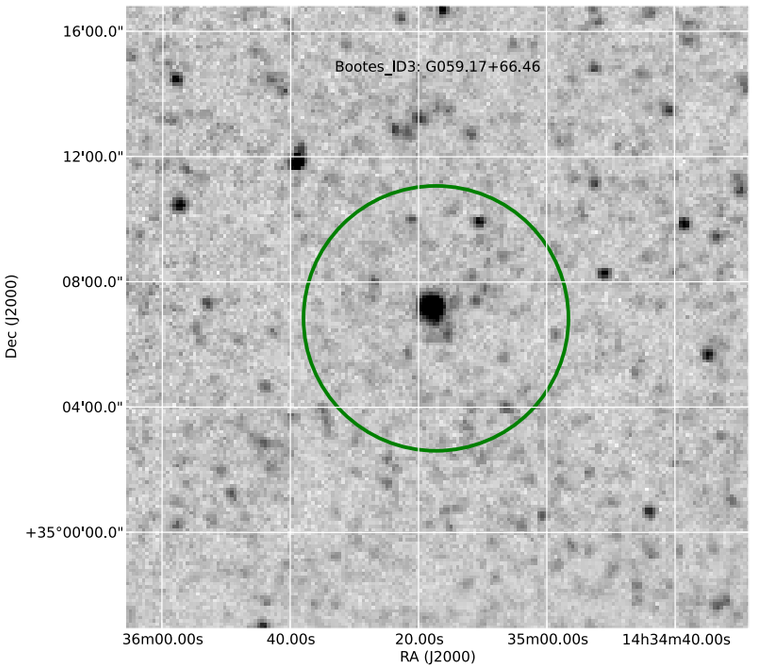
- Expect three classes of sources to be detected by Planck in these fields:
  - Bright nearby galaxies
    - Appear as bright sources in HerMES
  - High latitude cirrus
    - Appear as extended diffuse emission in HerMES
  - Candidate protocluster ‘clumps’
    - Appear as overdensities of less bright sources

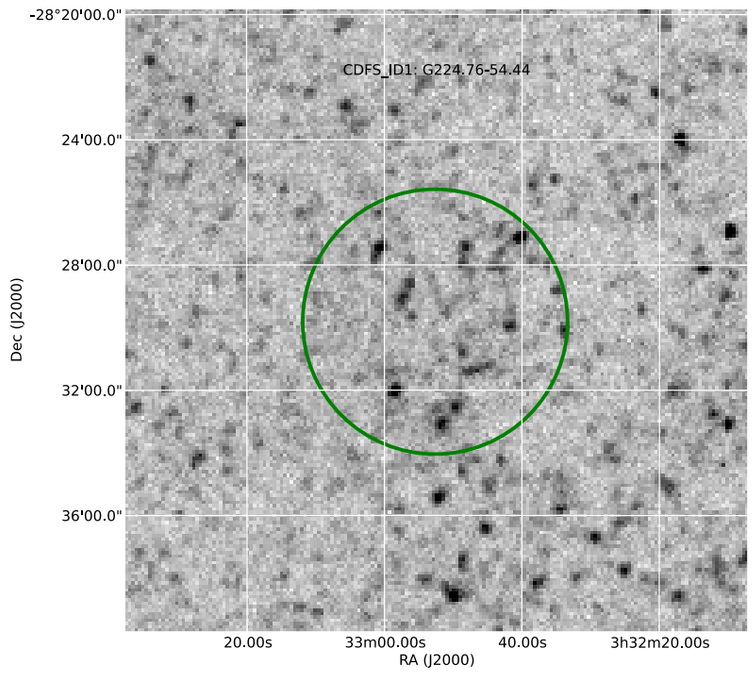
Example Planck Sources

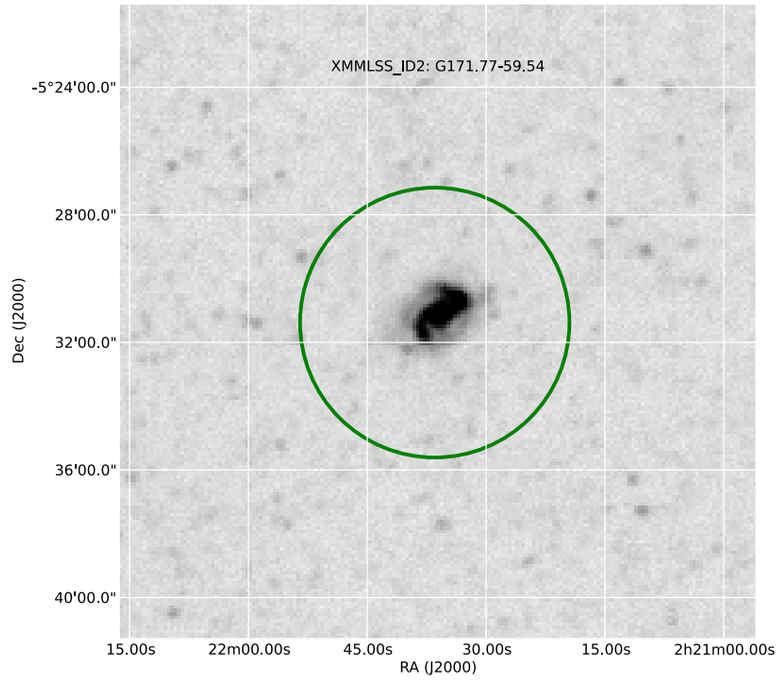
250 micron images of HerMES Planck Sources

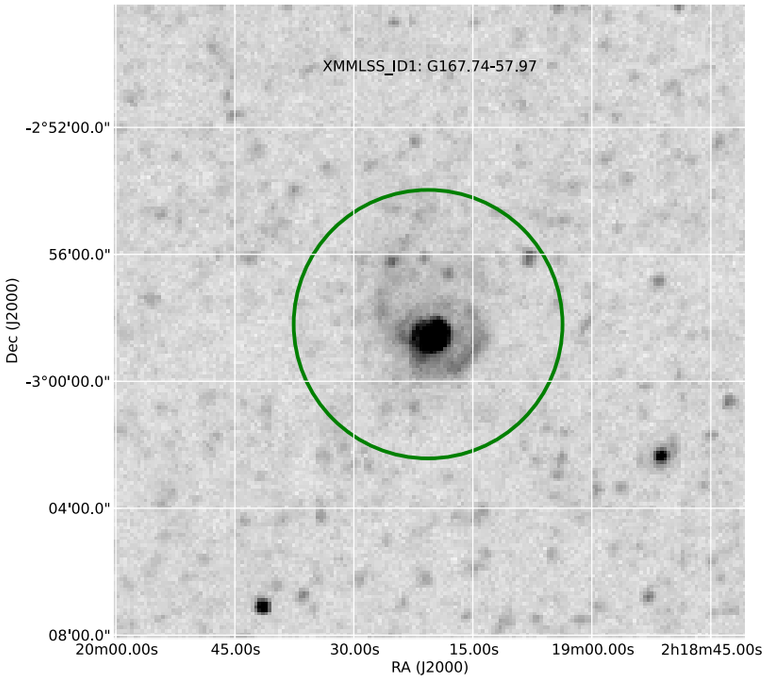






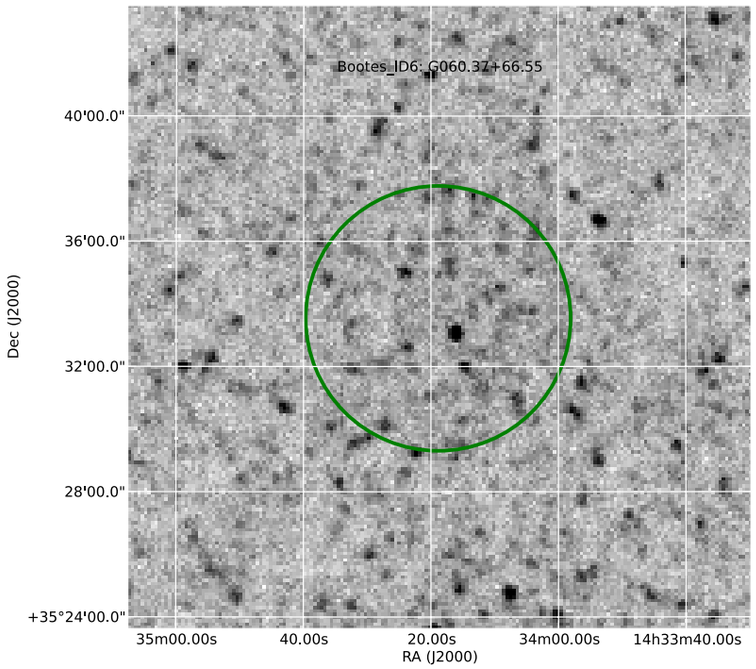


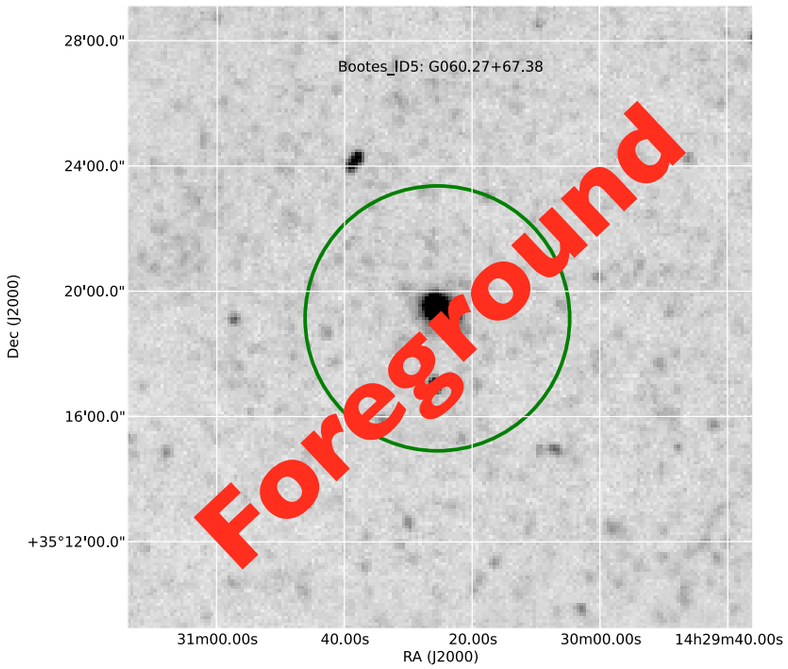


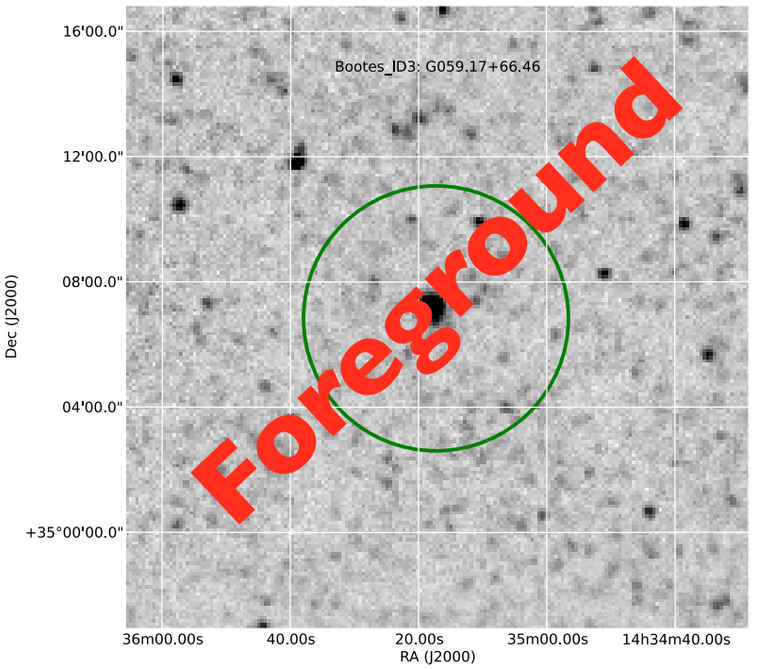


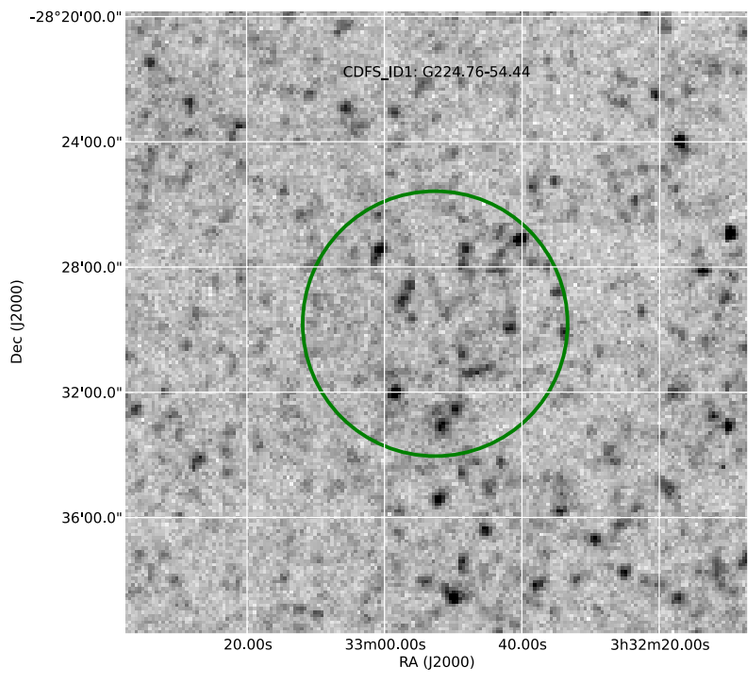
Example Planck Sources

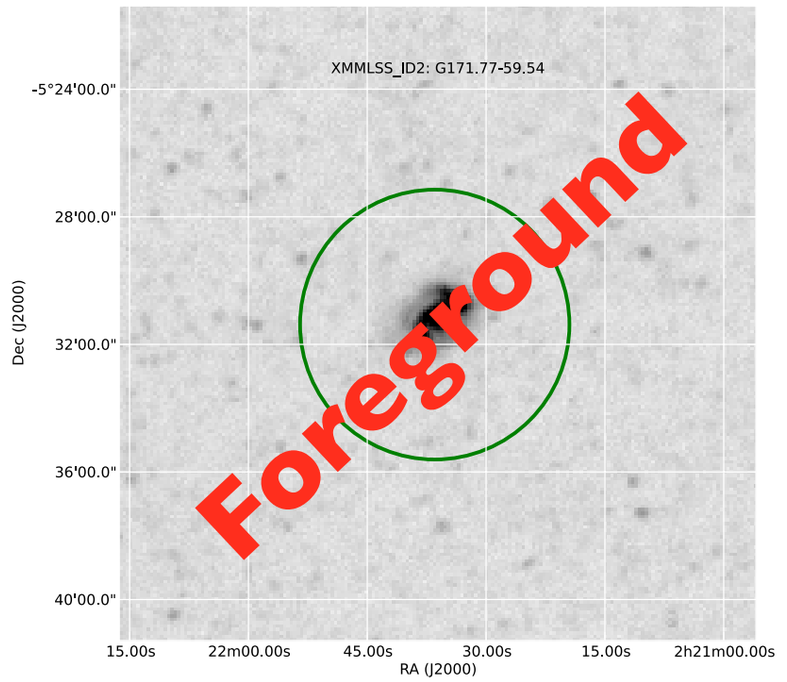
250 micron images of HerMES Planck Sources

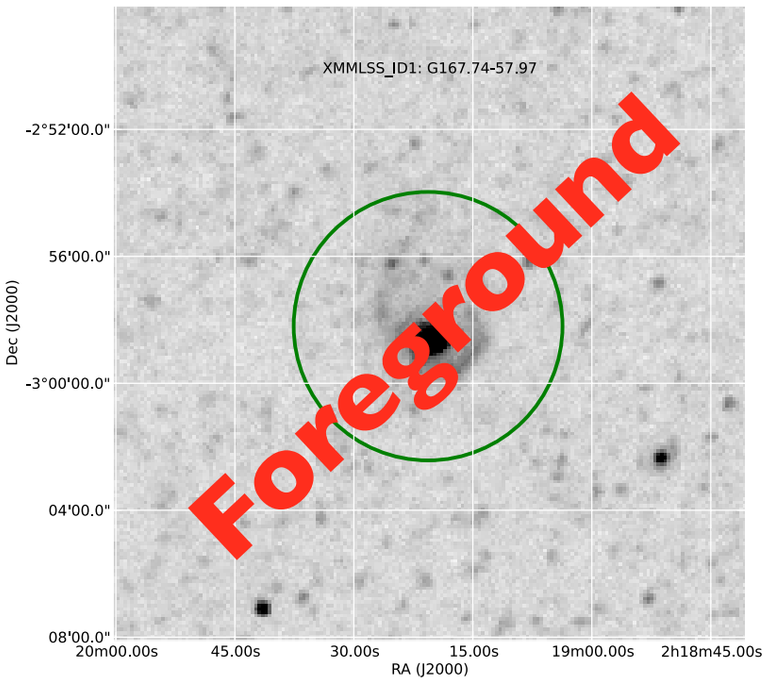










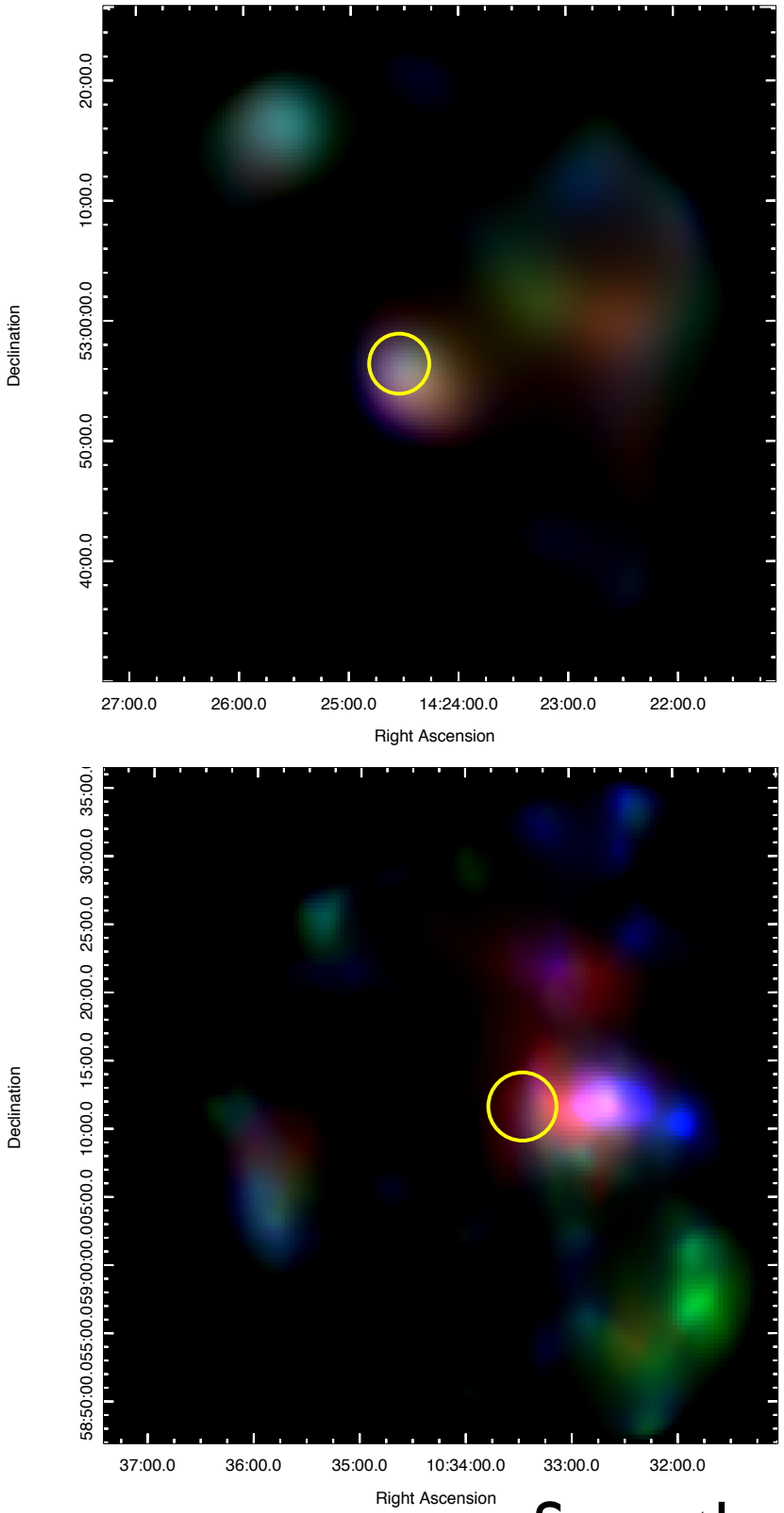


Results Summary

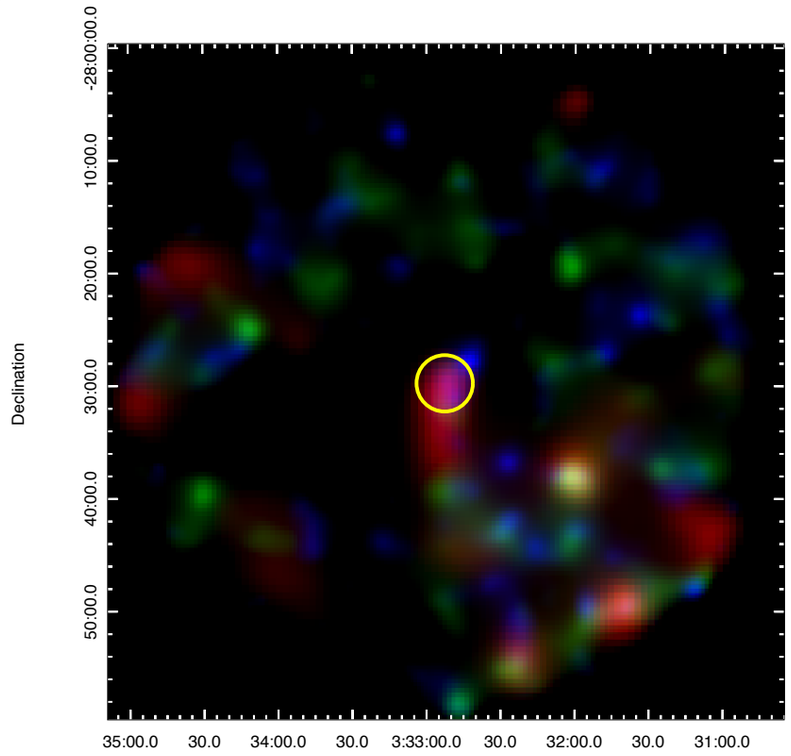
- For 4 well studied HerMES fields (XMMLSS, Bootes, Lockman-SWIRE, CDFS-SWIRE) find:
  - 16 Planck Sources
  - 12 foreground sources (galaxies + Mira)
  - 4 clumps in ~90 sq. deg. => 1 per 22.5 sq. deg.
    - Not all HerMES fields yet included
  - No cirrus sources in this list

Clements et al., MNRAS in press

HerMES Catalog Overdensities

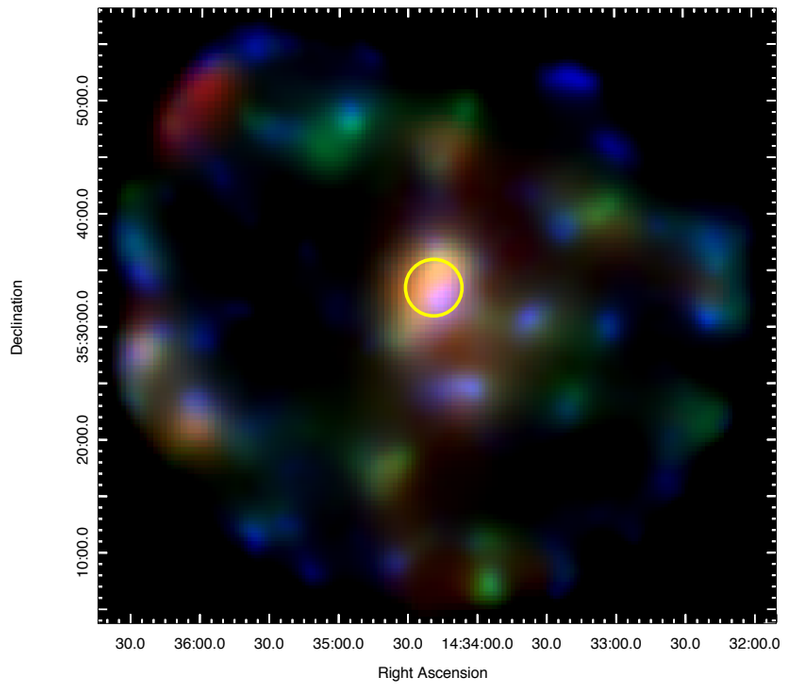


EGS



CDFS

Lockman



Bootes

Smoothed, flux weighted catalog overdensity image
3 colour:B=250micron G=350micron R=500micron

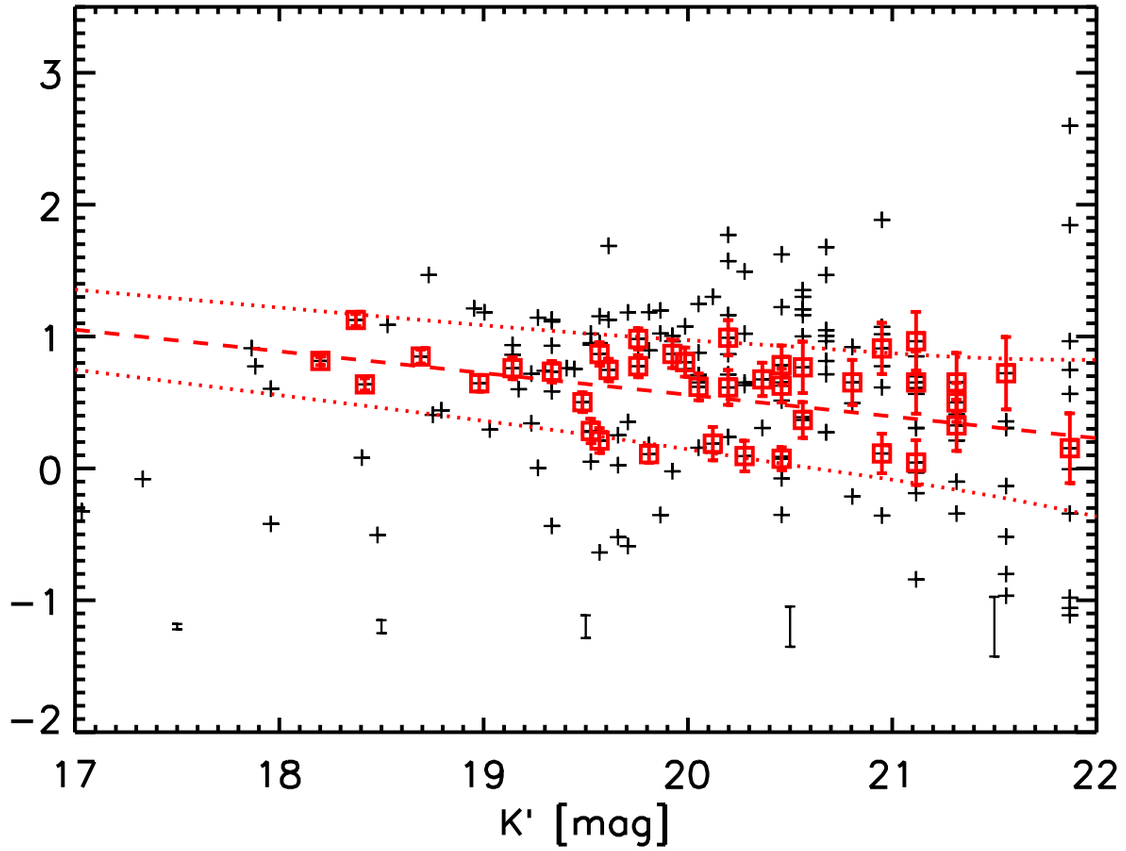
Herschel & Planck Analysis

- Sources are overdensities of dusty galaxies
- Colours in Herschel and Planck suggest high redshift (z>~1)
- Exactly what would be expected for the proposed dusty protoclusters

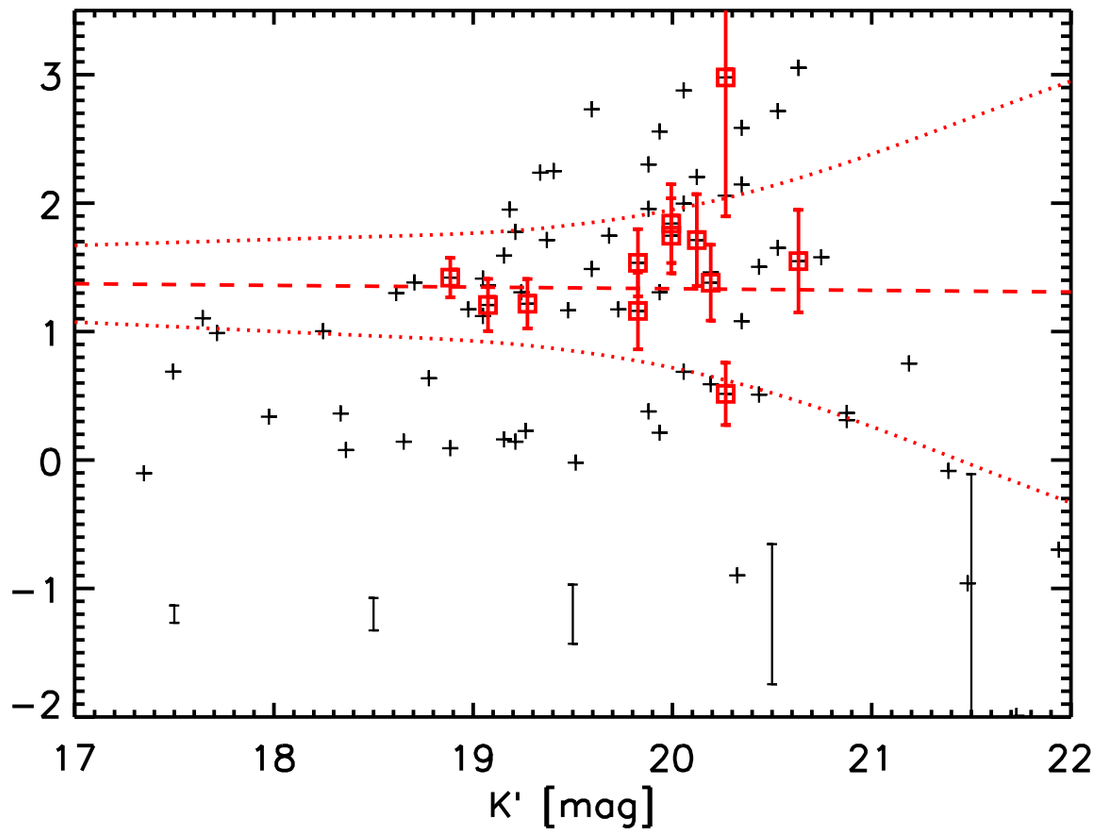
Followup

- Plentiful ancillary data exist for the CDFS and Bootes clumps
- Near IR J & K imaging for the EGS and Lockman clumps were obtained at TNG
- Allows us to look for evidence of cluster in CMD or in photo-z distribution

Results: Red Sequences



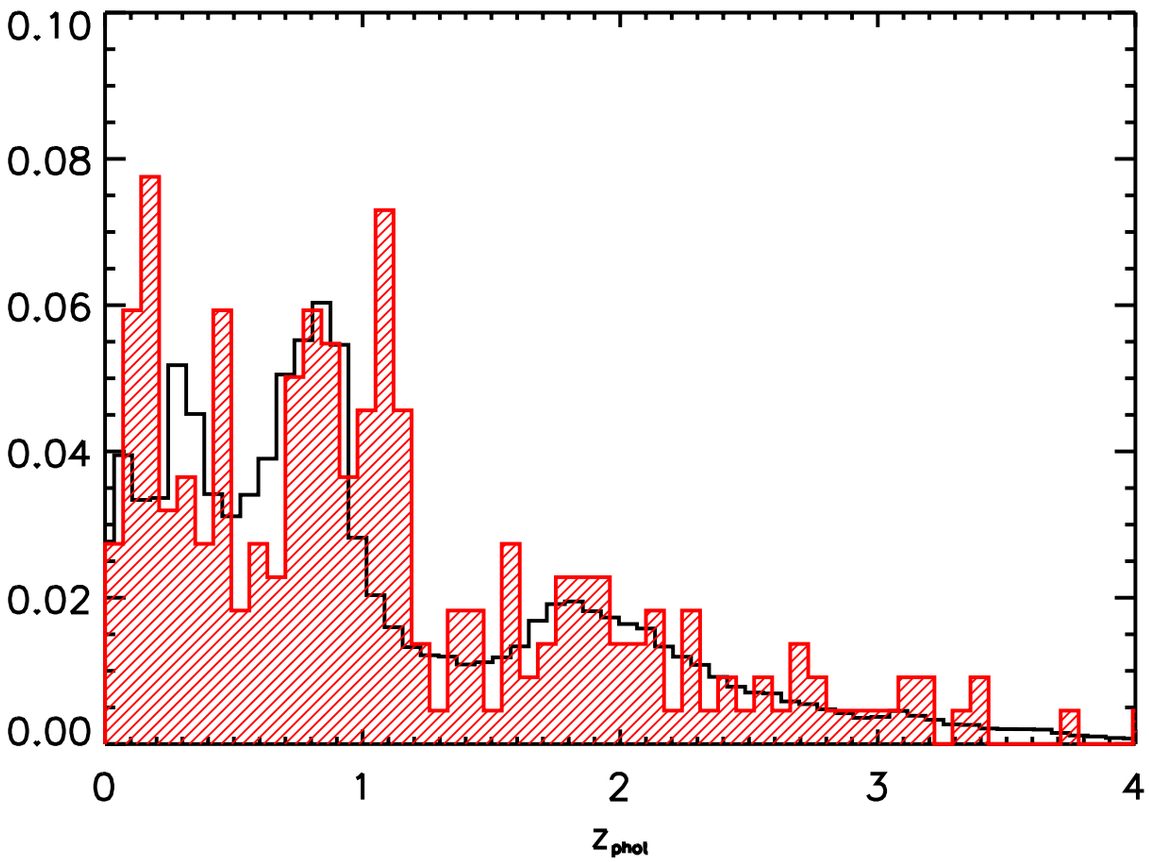
EGS: z~0.8



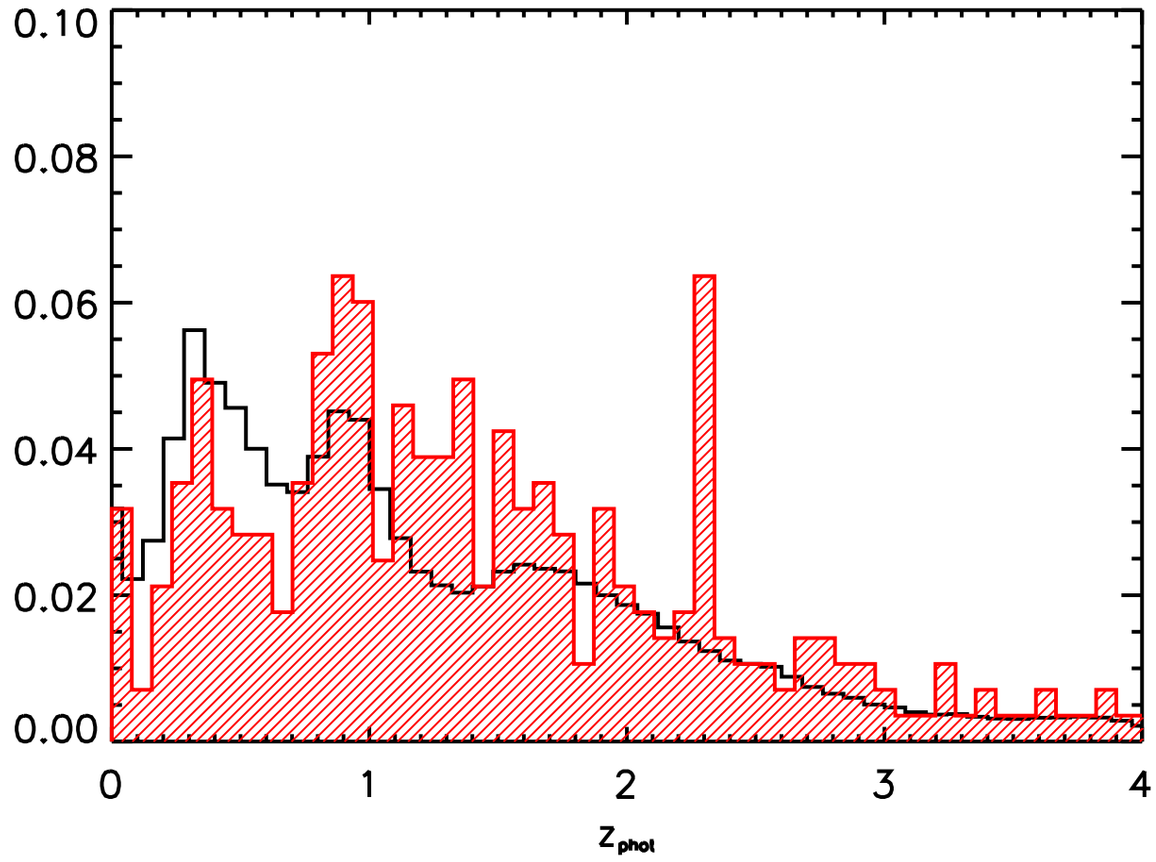
Lockman: z~2.0

Black = field, red = in Planck beam

Photo-z



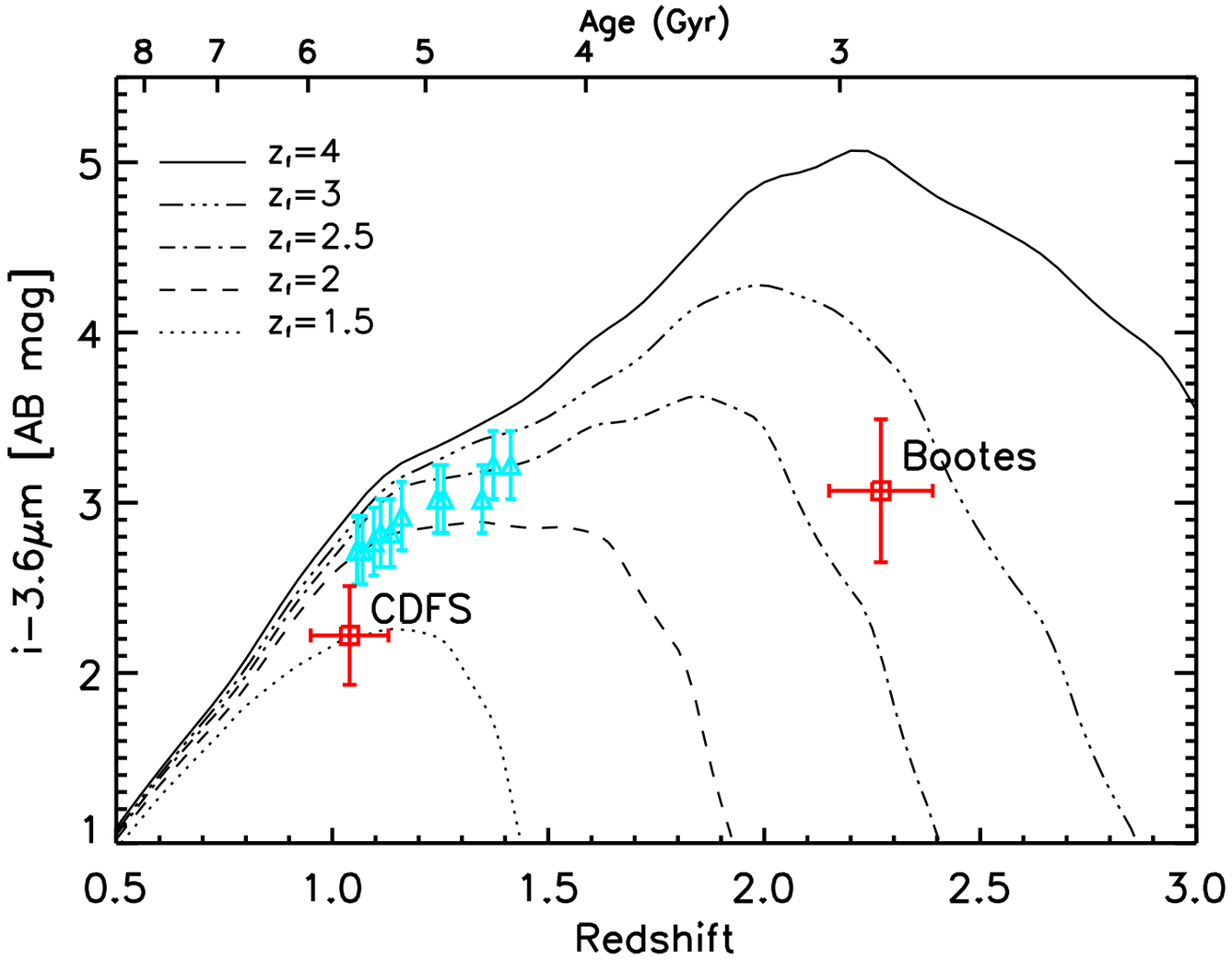
CDFS: z~1.1



Bootes: z~2.3

Cluster Ages

- Can use results on these high z starforming clusters to examine aspects of cluster evolution

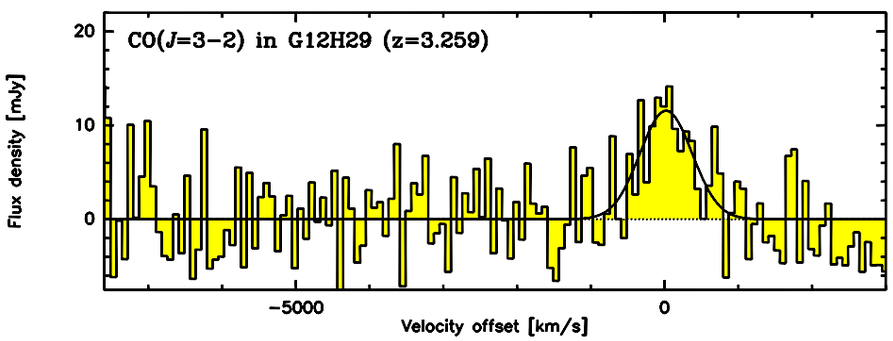


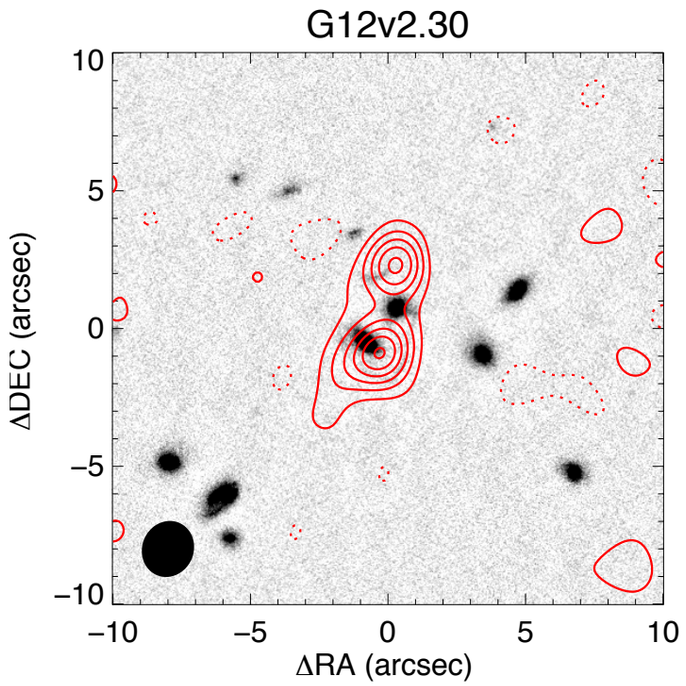
Colour vs redshift for 2 clumps & ISCS clusters compared to 4 different current ages

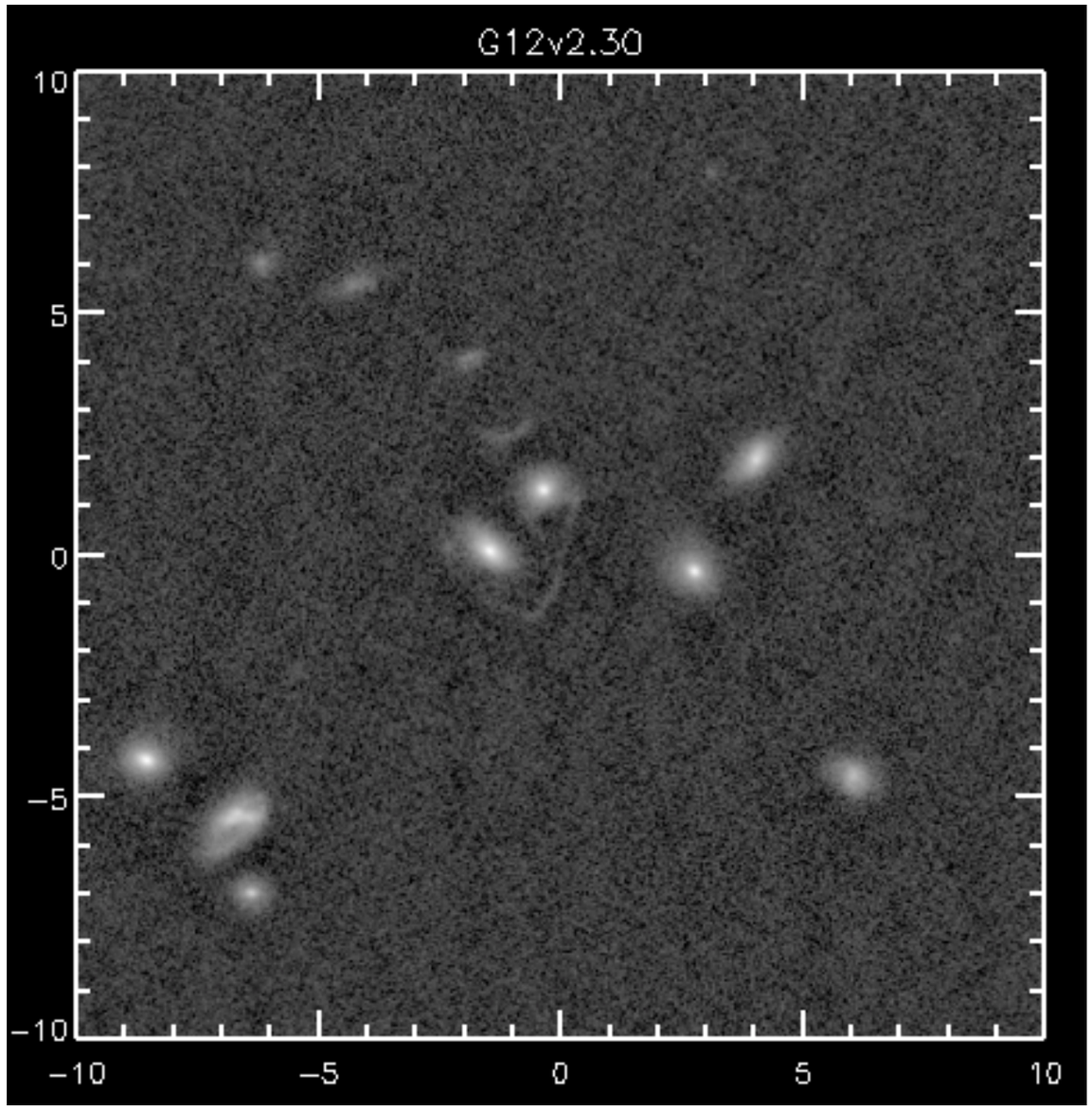
Clements et al. in press; Braglia et al. in prep

H-ATLAS Clumps

- Herranz et al. 2012 identify 1 clump in H-ATLAS GAMA fields
- Associated with z=3.26 lensed galaxy G12H29 in Fu et al. 2012

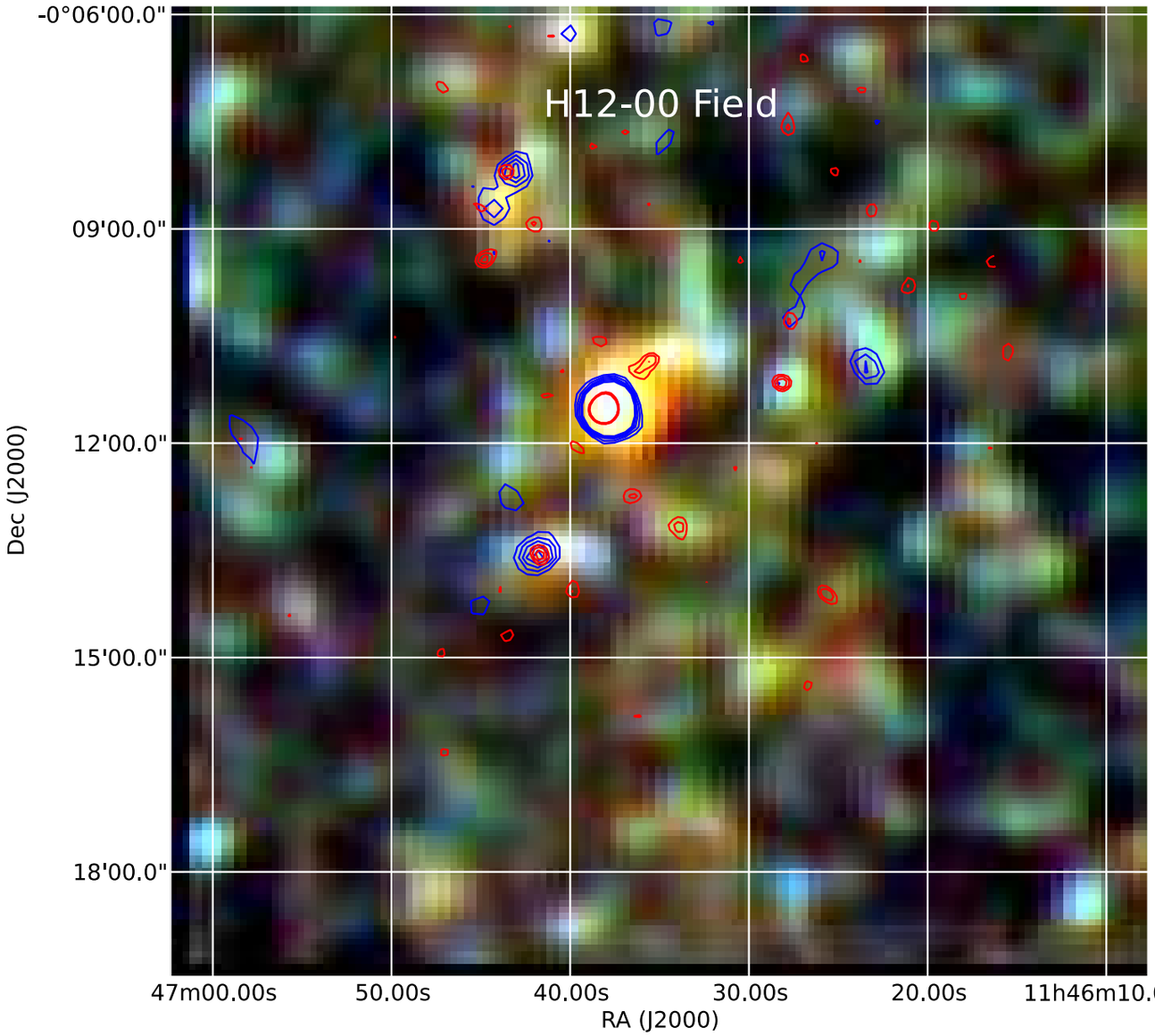


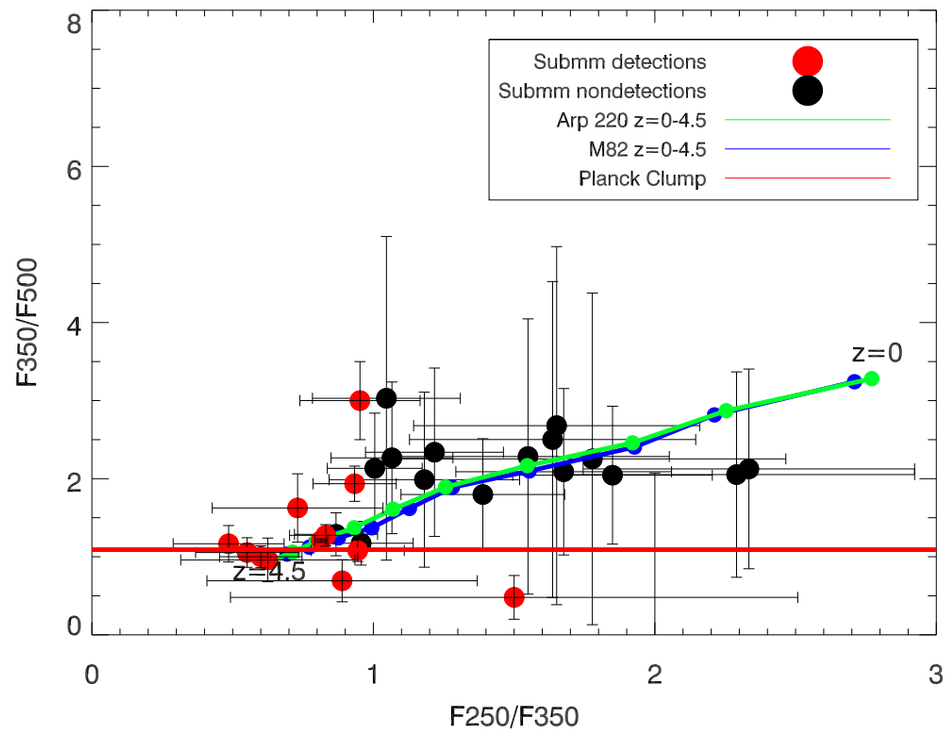


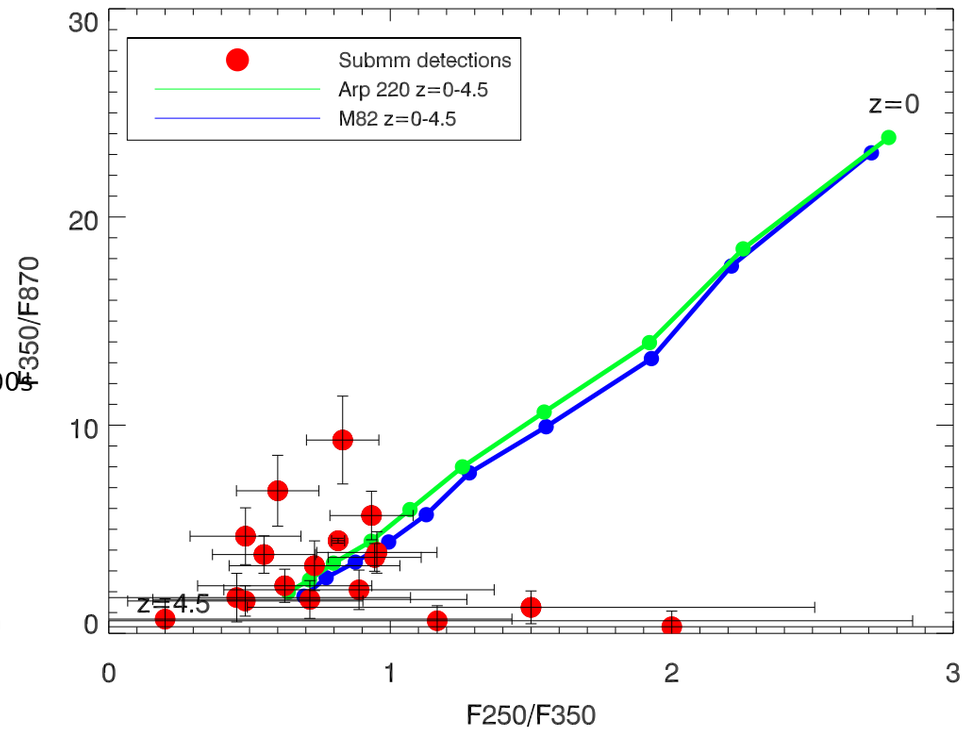


Is the clump at z=3.26?

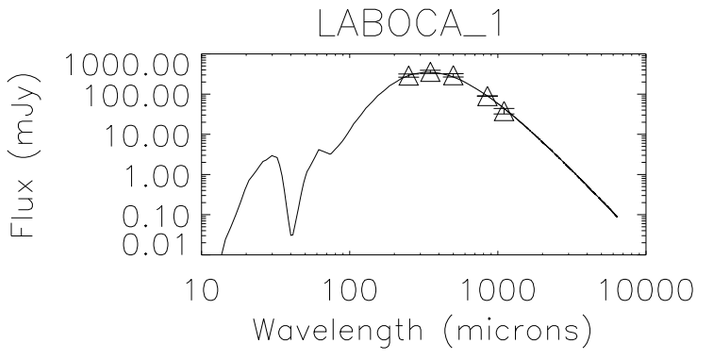
- Submm observations provide extra fluxes for sources around G12H29

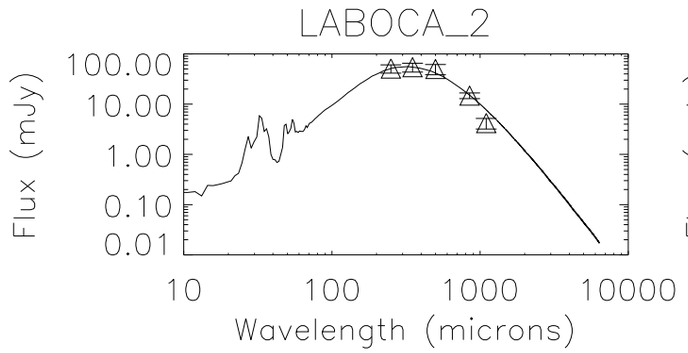


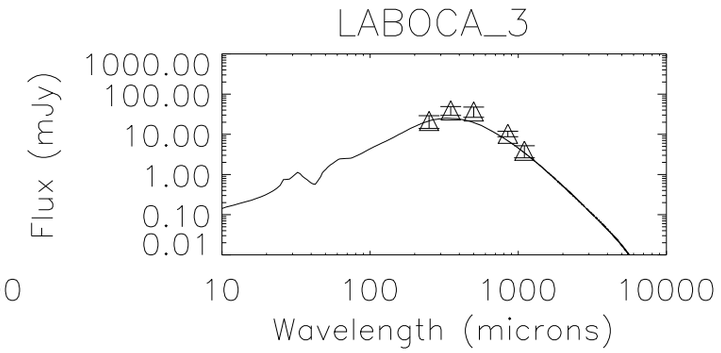


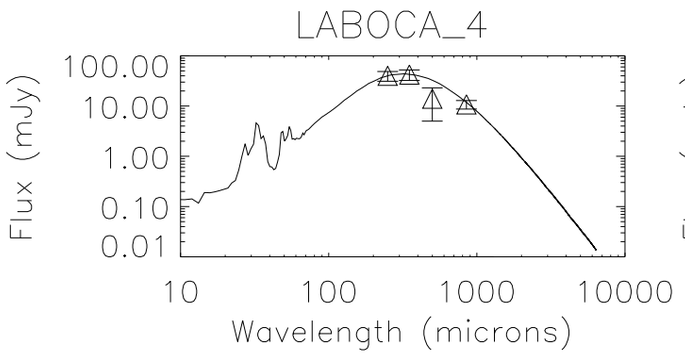


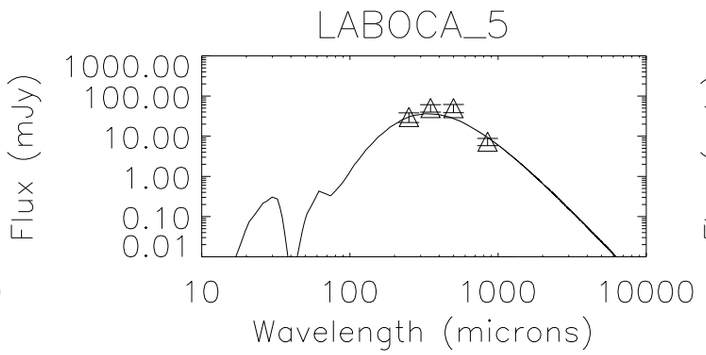
Herschel & Submm colours suggest Submm detections at similar z to lens

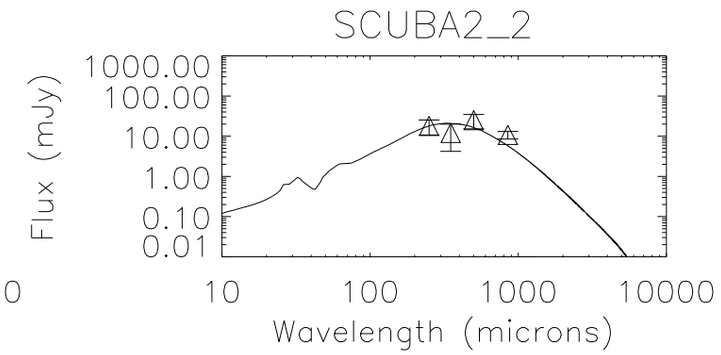


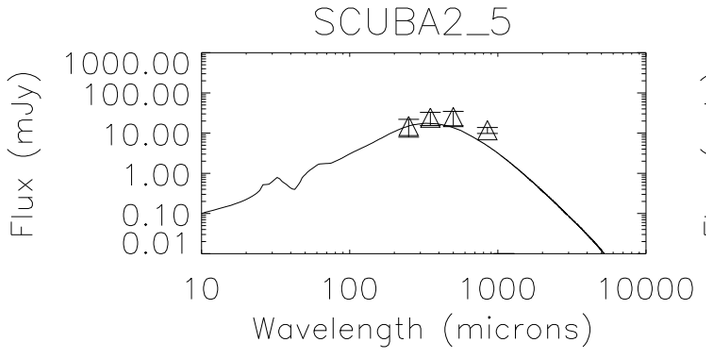


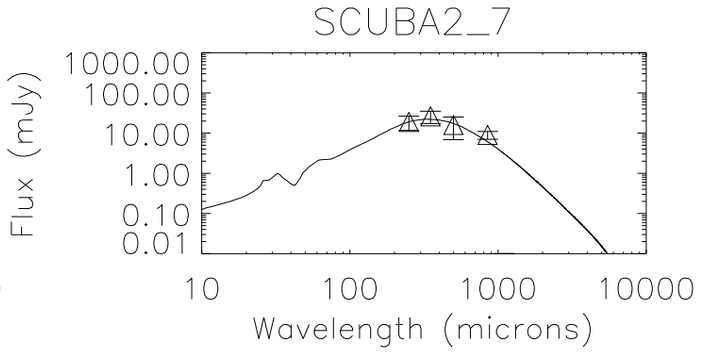


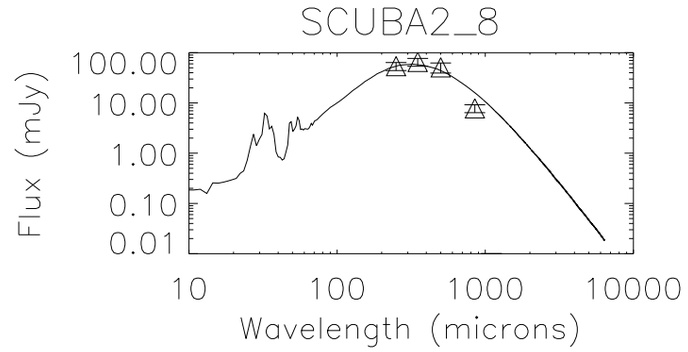


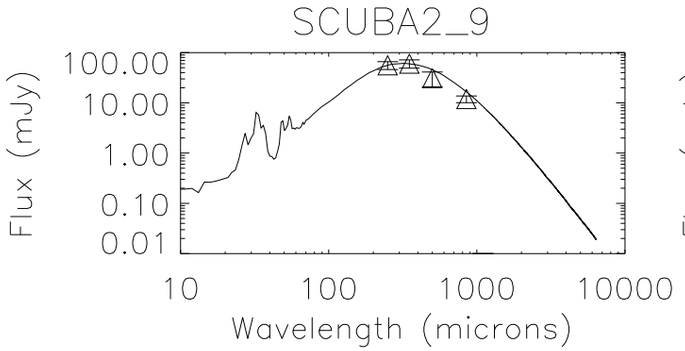


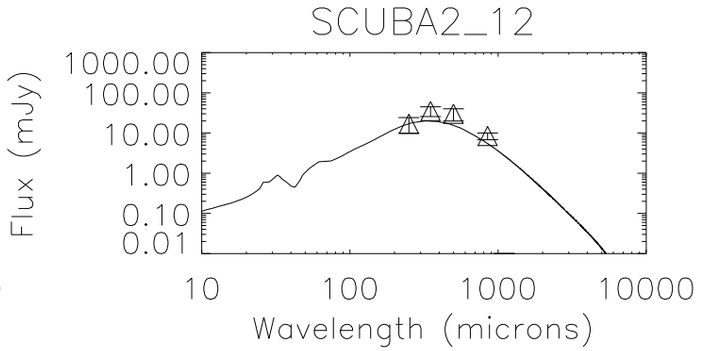








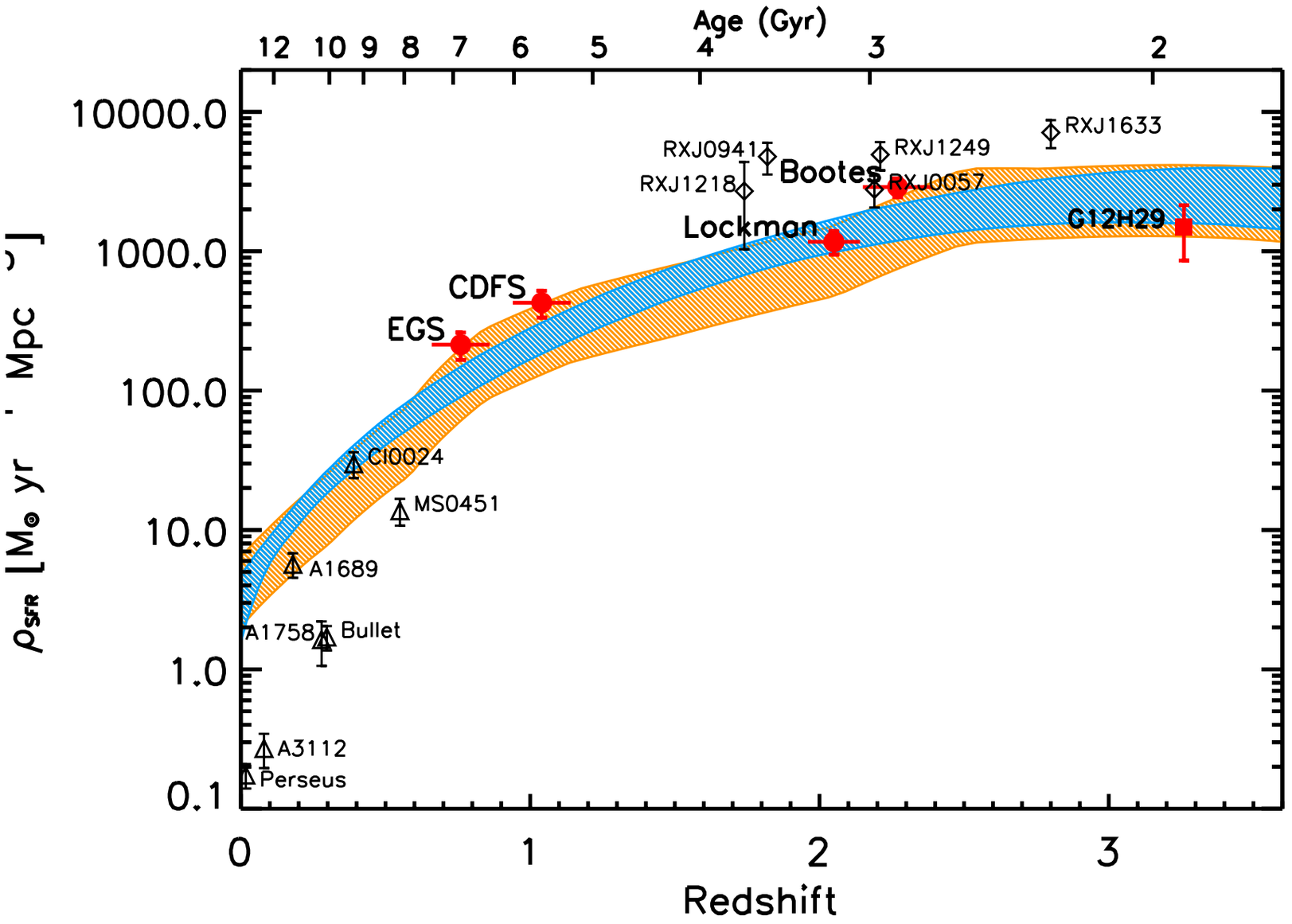




Submm photo-z fits all consistent with 11 companions lying at same z as lensed source: z=3.26

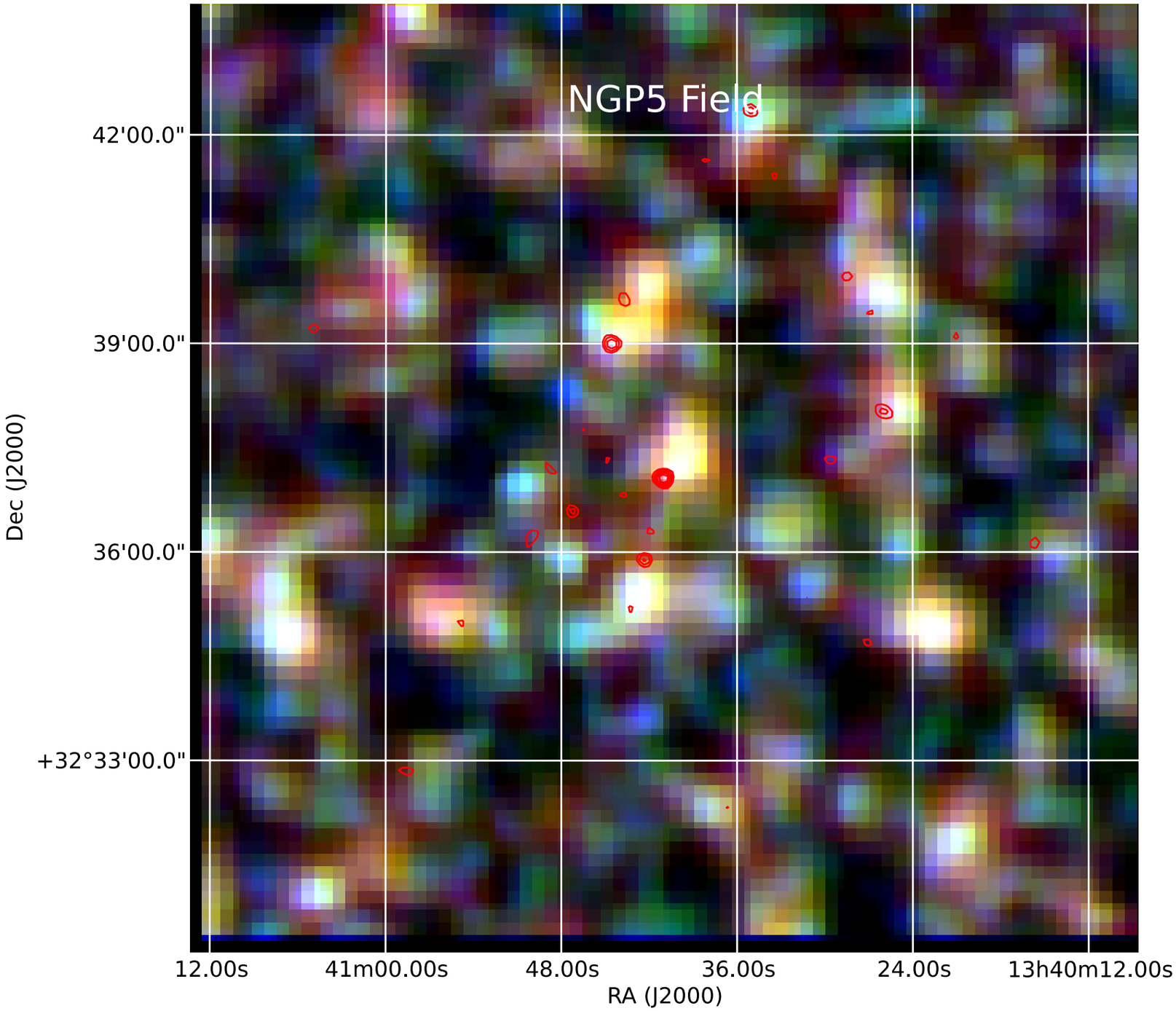
The SFRD of Clusters

- Compare with field SFR density evolution again
- Evolution from high z to z~1.2 match, but cluster SFRD drops at lower z
- What happens at higher z?



Field SSFR from Hopkins et al. 2006 (blue) and Bouwens et al. 2011 (orange)

More to Come!


NGP5 Field
42'00.0"
39'00.0"
36'00.0"
+32°33'00.0"
Dec (J2000)
12.00s
41m00.00s
48.00s
36.00s
24.00s
13h40m12.00s
RA (J2000)

Conclusions

- Combining Planck & Herschel allows the discovery of ‘clumps’ of dusty galaxies
- Appear to be high z clusters with many members going through simultaneous starbursts, some involve lensing
- Clusters found in this way at higher z than conventional searches allow