Searches for z>7 galaxies in the mid-IR - a prelude to JWST

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Massive galaxies at high-z

- Galaxies at z~6 surprisingly easy to detect with IRAC (Eyles et al., Yan et al., Wiklind et al…).
- 2×10^{10} solar masses at z~6 is ~1μJy at [3.6]
- But what about higher-z?
- Lack of large area, ultradeep IR surveys a limitation
- A few candidates from HUDF (Bouwens & Illingworth 2007), emission line survey (Stark et al 2007), but SRFD and stellar mass density very uncertain.

Strategies: emission line surveys

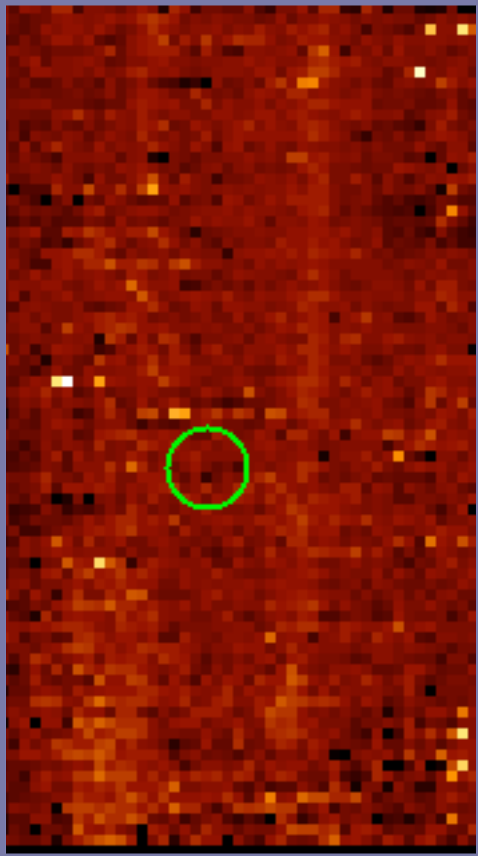
- Lyα relatively easy but Lyα flux very uncertain if reionization incomplete
- Hα much better in some respects
  - Not absorbed by IGM
  - No resonant trapping/dust absorption
  - But redshifted to mid-IR (higher background than near-IR in space, can't be done from the ground)
- Spitzer/IRS could, in principle, find Hα emitters at z>7, but only the brightest would be detectable.

Where are good places to look?

- Candidate Ly-alpha emitters at z~8 (Stark et al. 2007)
- Cluster caustics/critical lines (blind search)
- Objects with excesses in band-3 of IRAC undetected in I/z-band with ACS.

Lyα candidate search

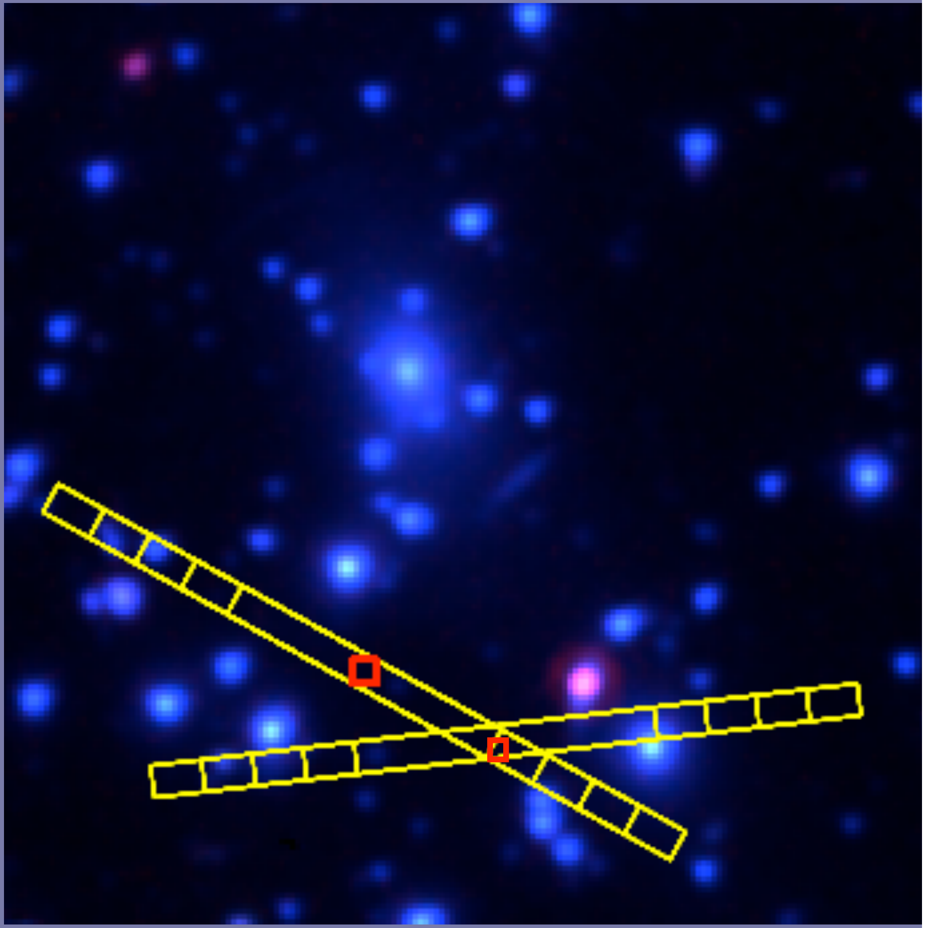
- Picked two objects from Stark et al. (2007) in Abell2219; c1, z=8.99, and c2, z=8.94.
- Neither detected to 3-sigma limits of 1-1.5x10^{-19}Wm^{-2} (c1,c2) in deep integrations, implying Hα/Lyα <~2,7 (cf CaseB = 0.1) - can rule out extreme Lyα absorption scenarios.



IRS SL 2D spectrum

Blind search

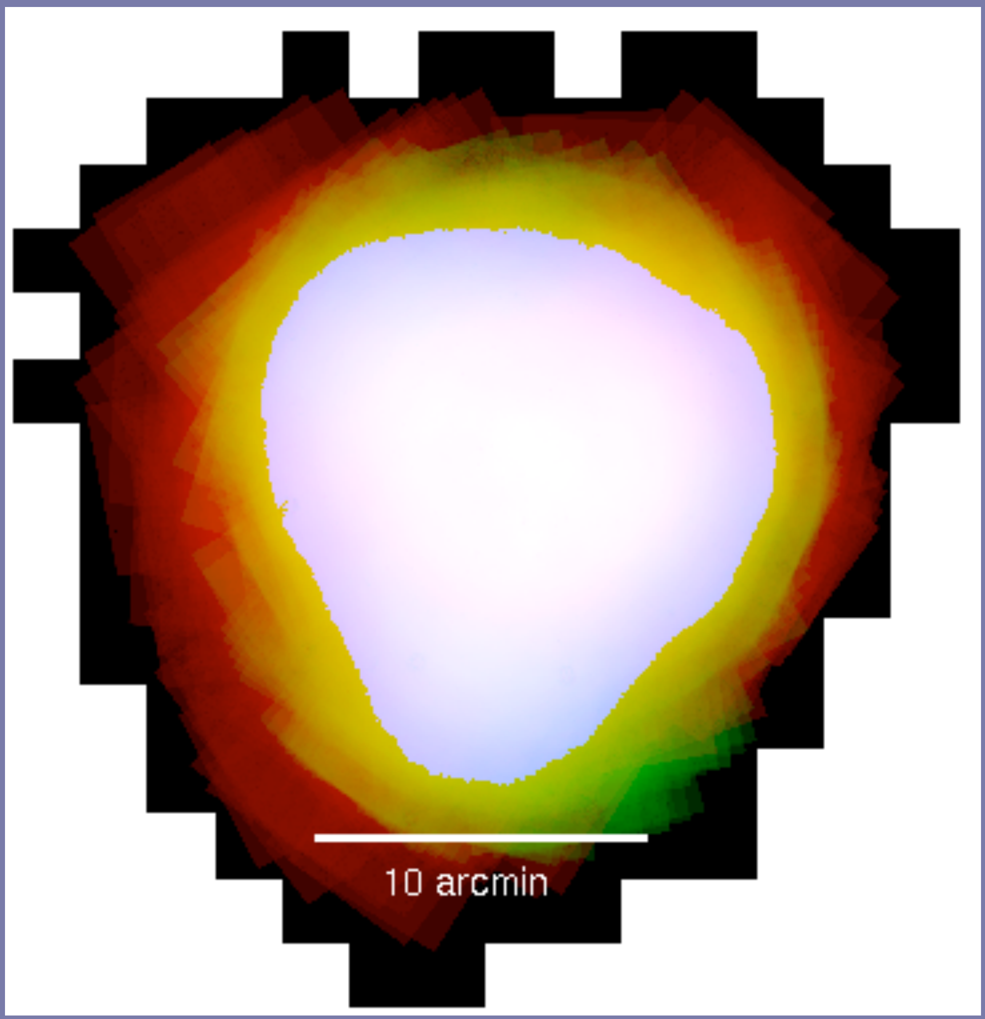
- Also search along slits close to caustics/critical lines for serendiptous objects in the A2219 observations and one slit position in A2218
- Total volume sampled at ~10x mag is ~100(10/μ) Mpc^3.
- Limiting SFR is ~40(10/μ)M sun/yr
- SFRD <~0.4Msun/yr/Mpc^3 (ignoring clustering)

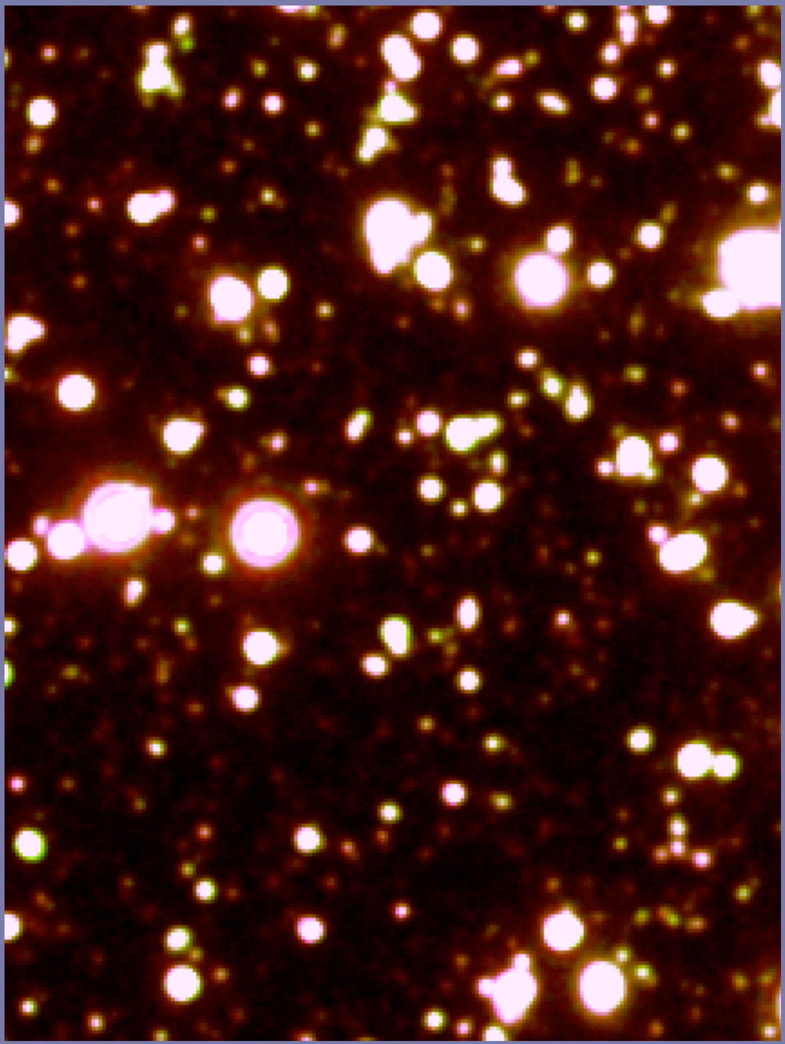


The IRAC dark field

- The IRAC shutter cannot be used in flight
- "skydarks" are therefore taken at a very low background region near the NEC.
- Good coverage at range of sky PAs means artifacts very effectively removed, PSF very smooth.
- Used inner 188 $arcmin^2$ (>10ks in first 2.2 years of data), depth of inner few $arcmin^2$ up to 100ks (>200ks by end of mission).
- ACS F814W data to AB~29 for point sources.
- Unfortunately no deep near-IR data so far, so results preliminary.

IRAC darkfield





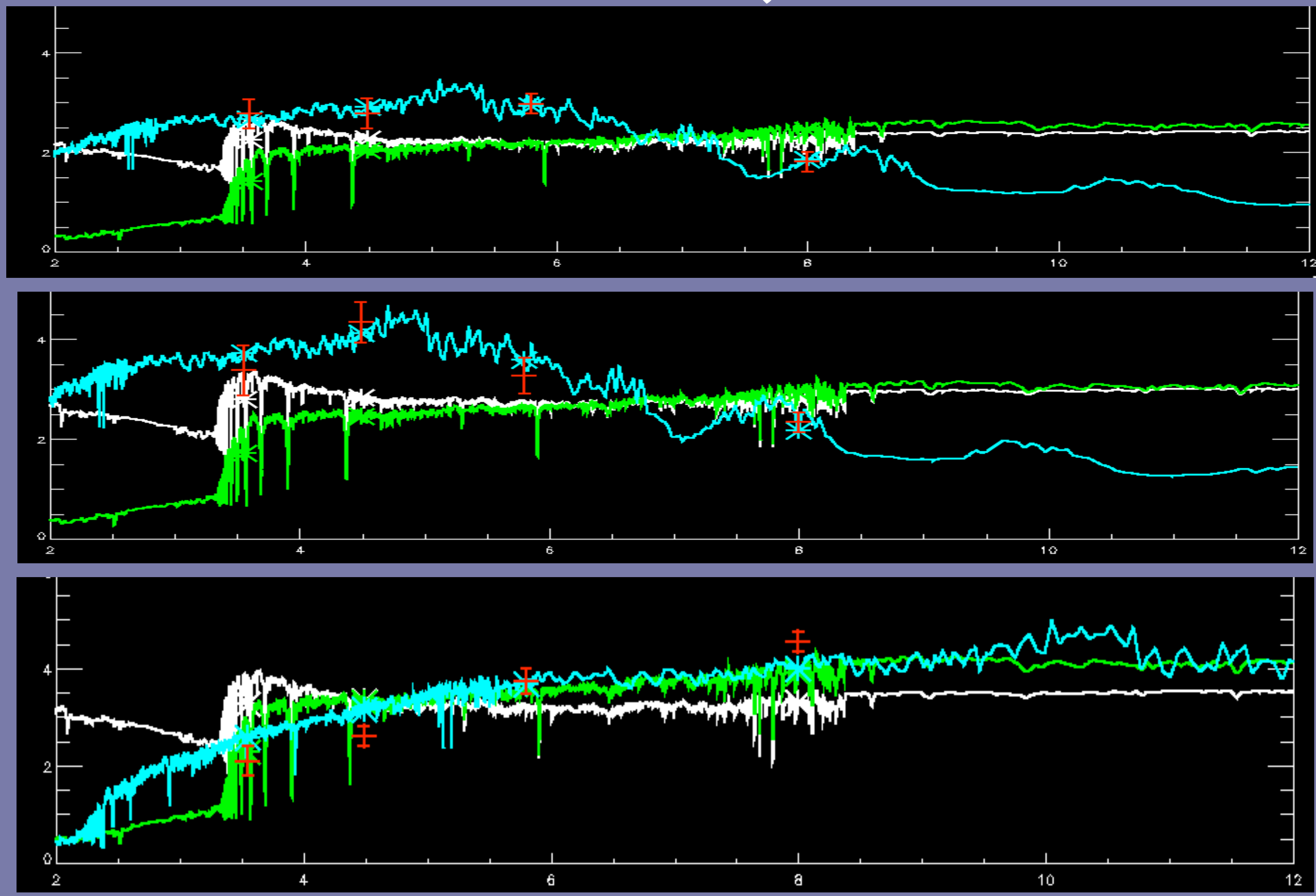
Selecting z~7 galaxies

- 30000 objects in dark field
- Start by rejecting all objects detected in ACS F814W, MIPS 24 and obvious blends, artifacts etc.
- Put in flux cut of 1μJy at [4.5].
- Leaves ~50 objects.
- ~50% complete.
- High-z objects still a minority. Most are just very red z~2-4 galaxies.

Filtering the candidates

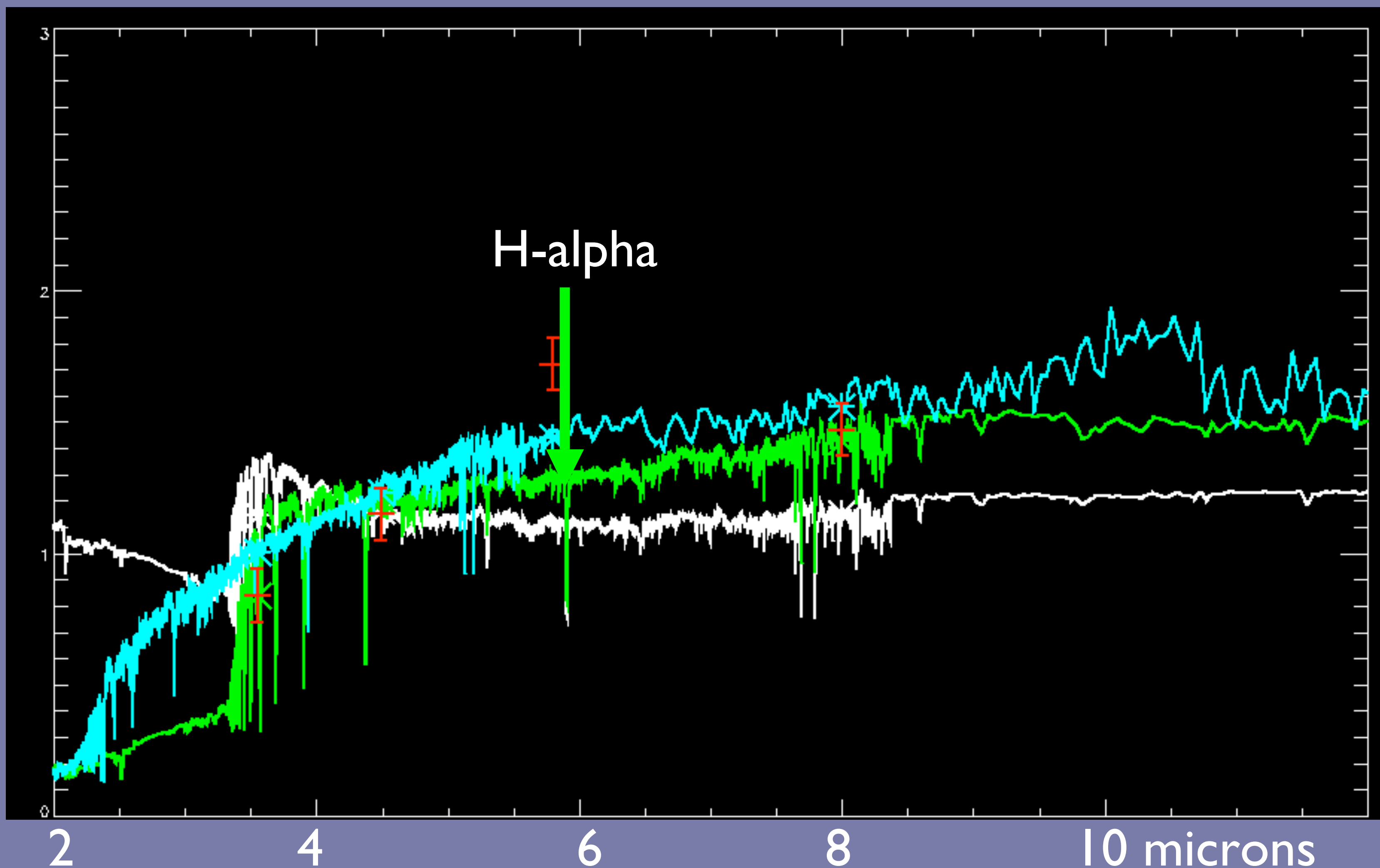
- Do a very simple photo-z. Allow for bump corresponding to H-alpha emission in the [5.8] band.
- Major contaminant are “bump 3” sources with the 1.6mu bump in the [5.8] mu band. Hence need for very accurate 4-band photometry, especially in the absence of near-IR data.
- But brown dwarfs have very different mid-IR colors

Low-z rejects



2 4 6 8 10 microns

z~7? example



Results

- 4 fair z~6.5-9 candidates
- Preliminary - obviously can do better with near-IR data (and really need spectra!).
- Derived stellar mass density (just from these objects) ~3-6x10^5 solar masses/Mpc^3, compared to 1-3x10^5 from 2 (much fainter) HUDF objects (Labbe et al 2008).
- Model predictions from de Zotti, Lapi, Bressan & Danese (p.c.): ~5.5 [4.5]>1muJy 6.5<z<9 objects in field.

Summary

- Hα emission in the rest-frame mid-IR is potentially important for quantifying star formation in luminous z>~7 galaxies.
- No resonant trapping problems, less affected by dust than UV or Lyα emission.
- Unaffected by GP trough absorption.
- High observed frame EWs will be large enough to affect broad-band photometry (see also Chary et al. 2005).
- Probably need JWST/MIRI to detect though…