The Environments of faint Ultra Steep Spectrum Radio Sources

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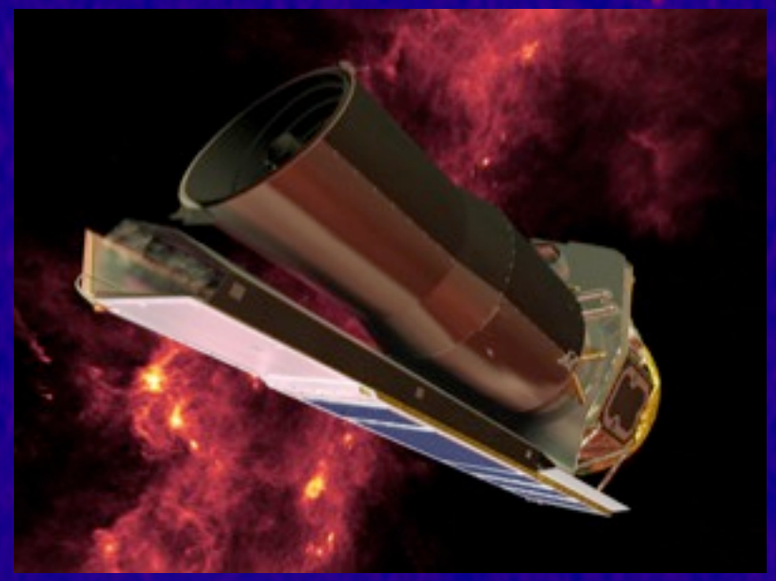
& the SERVS team



José Afonso
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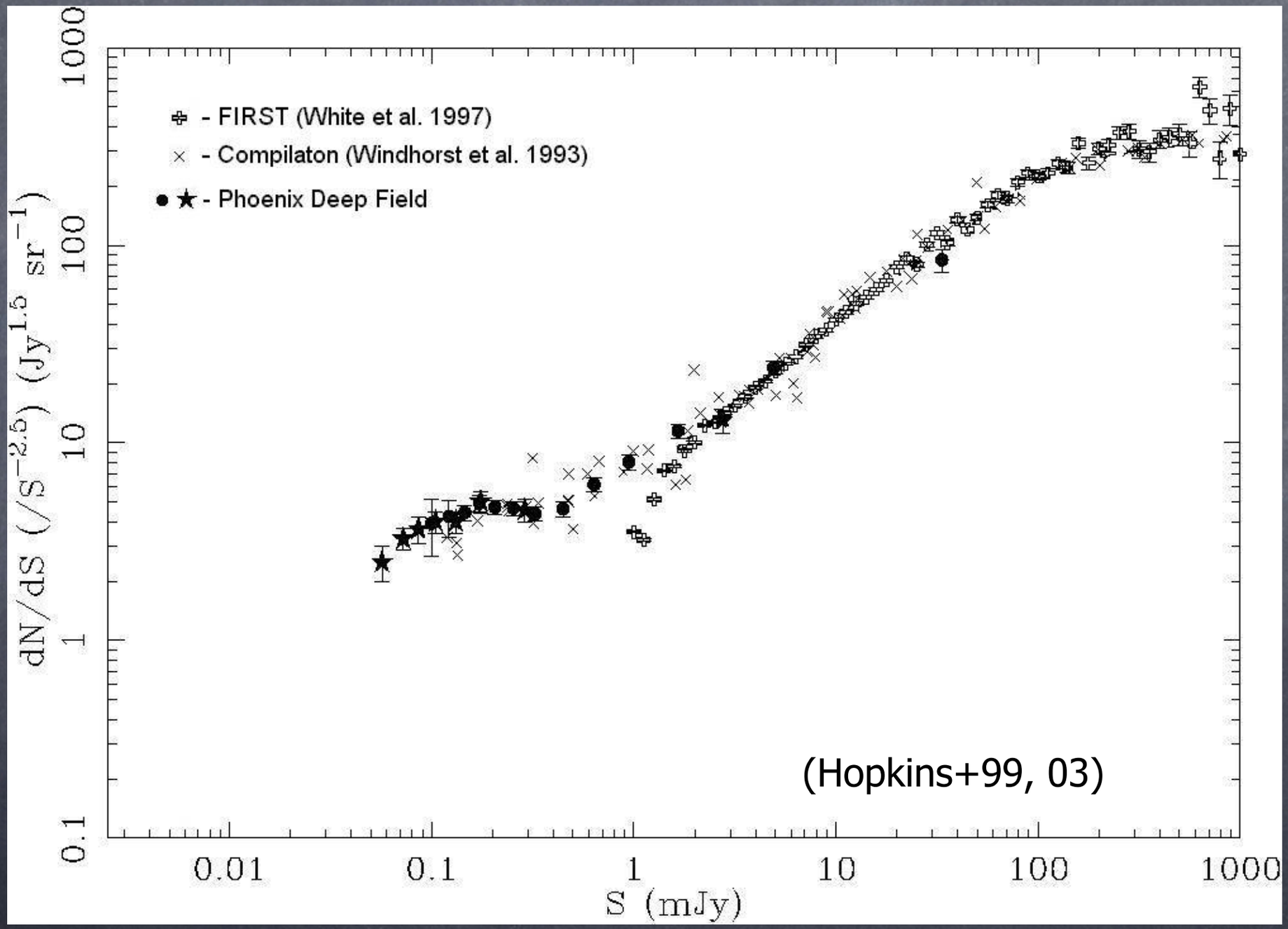
Growing-up at high redshifts: from proto-clusters to galaxy clusters · 2012 September 13, Madrid

The Radio Galaxy Population



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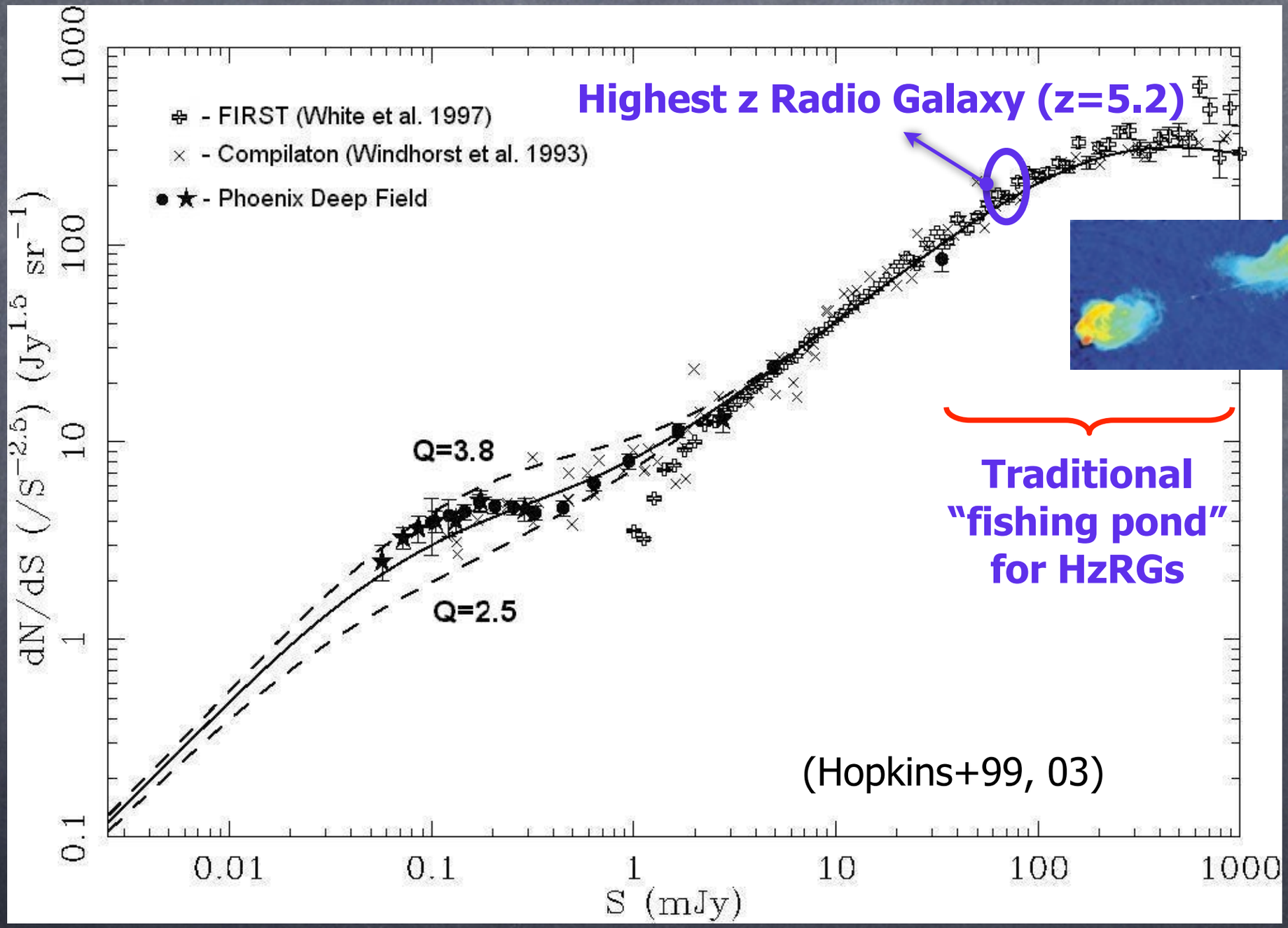


The Radio Galaxy Population

Why High-z Radio Galaxies (HzRGs)?

1) Among the most luminous galaxies at any redshift

2) Associated with the most massive systems

3) Progenitors of brightest cluster ellipticals

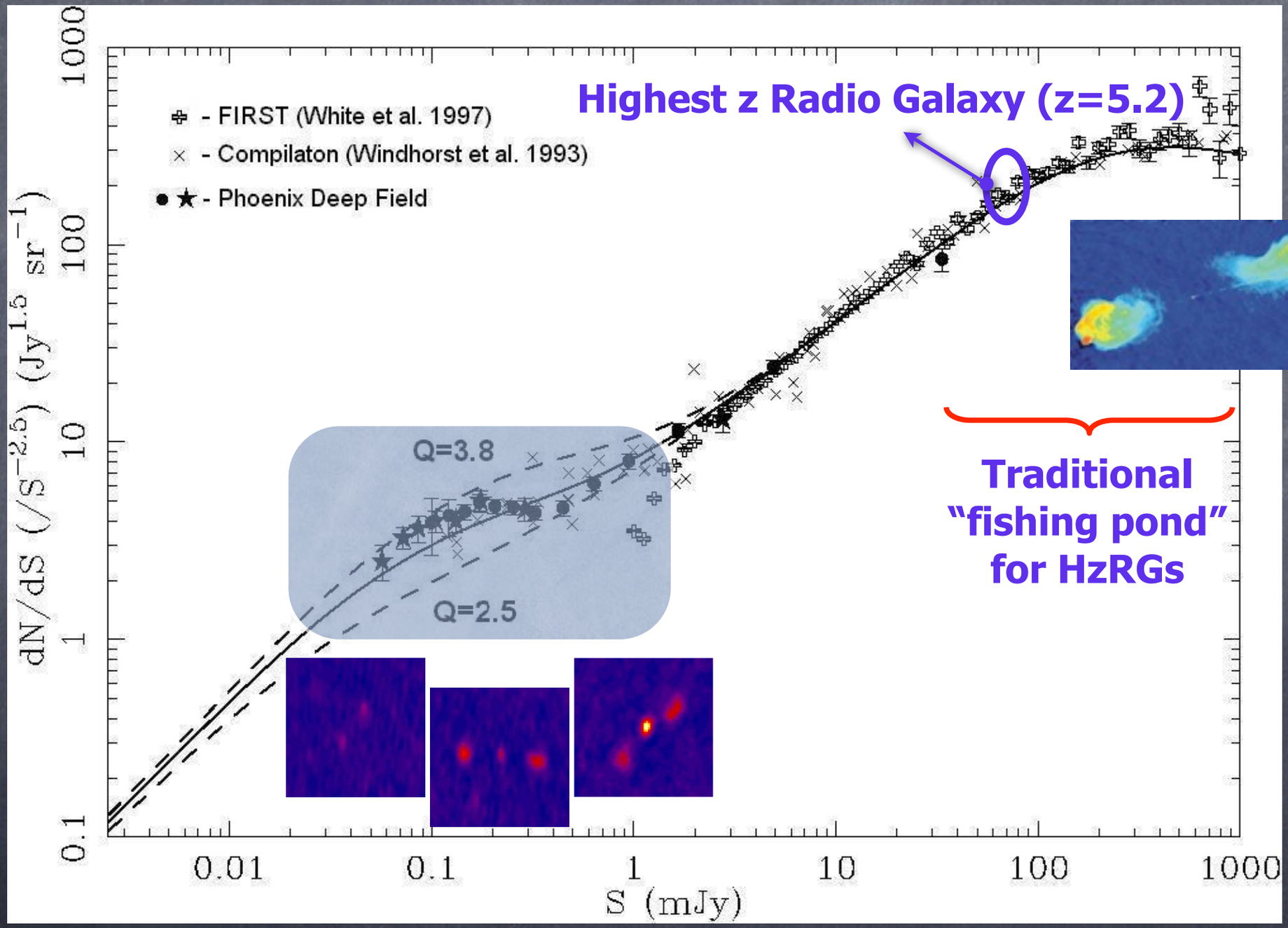
4) Track proto-cluster environments

5) May show large amounts of dust, and sub-mm detections imply violent SF (~1000 $M_\odot$/yr, Reuland+03, 04, Seymour+12)

6) May show large gas reservoirs (Ly-α halos)

All this at z ~ 2-5...

The Radio Galaxy Population



The ins and outs of HzRGs at μJy levels

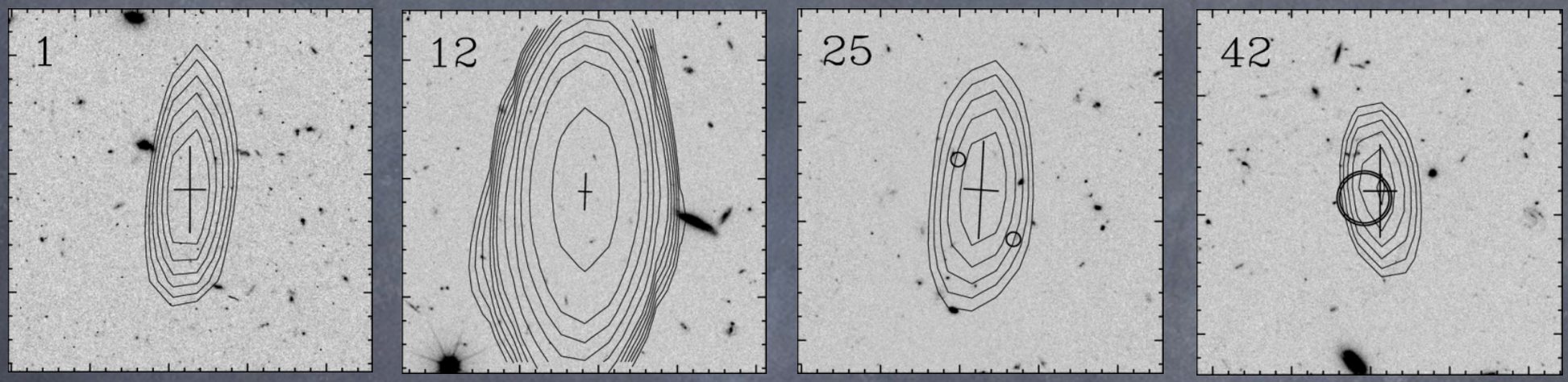
The μJy level is not necessary to reach high z's...

...but necessary to be sensitive to more numerous objects;

Need to seep through a huge number of lower z sources (common at μJy levels);

How to "avoid" the "low"-z radio population?

1) Sources non-detected in the optical to very deep levels



(eg, CDFS, Afonso et al 2006)

How to “avoid” the “low”-z radio population?

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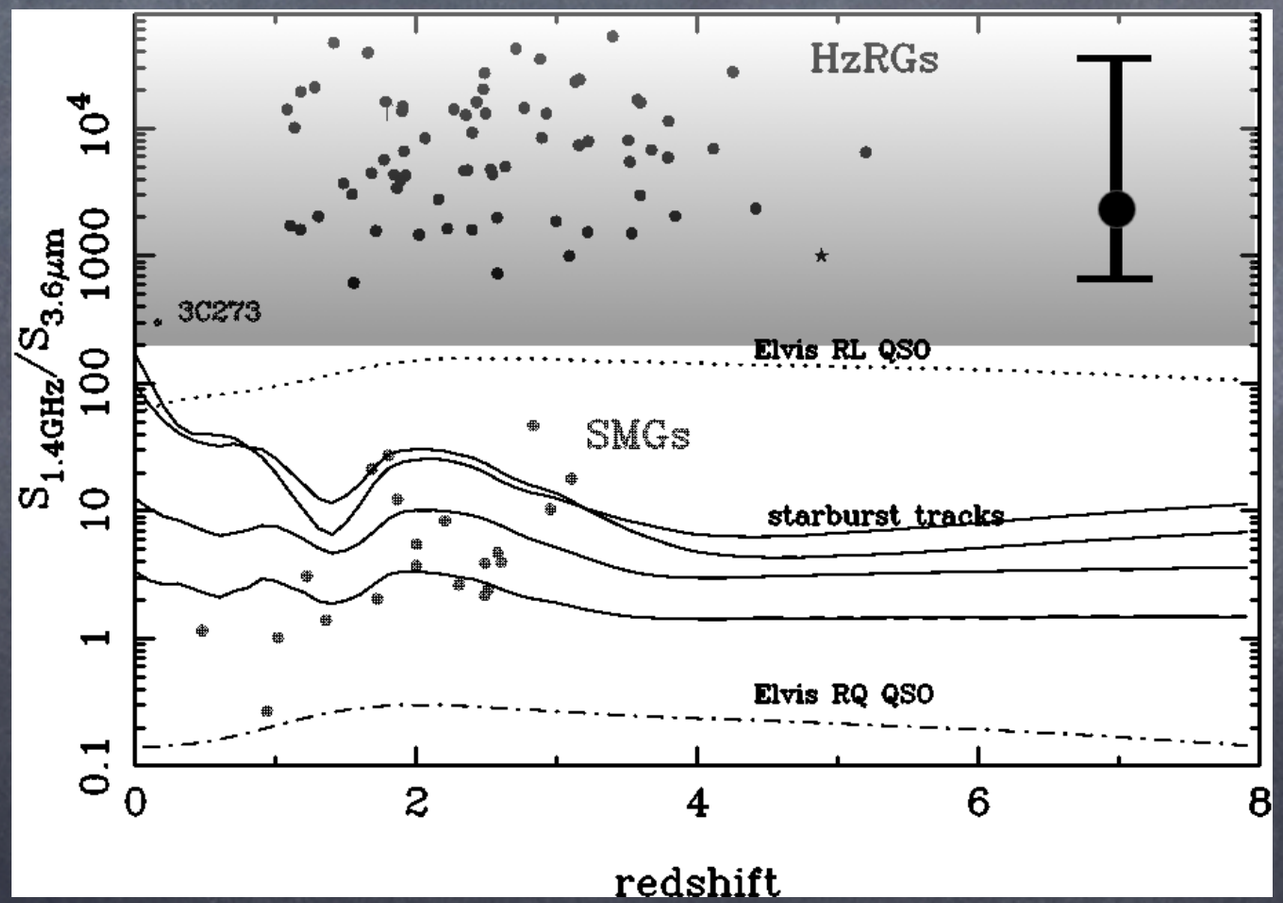
2) Infrared Faint Radio Sources



(Norris+11, Seymour+)

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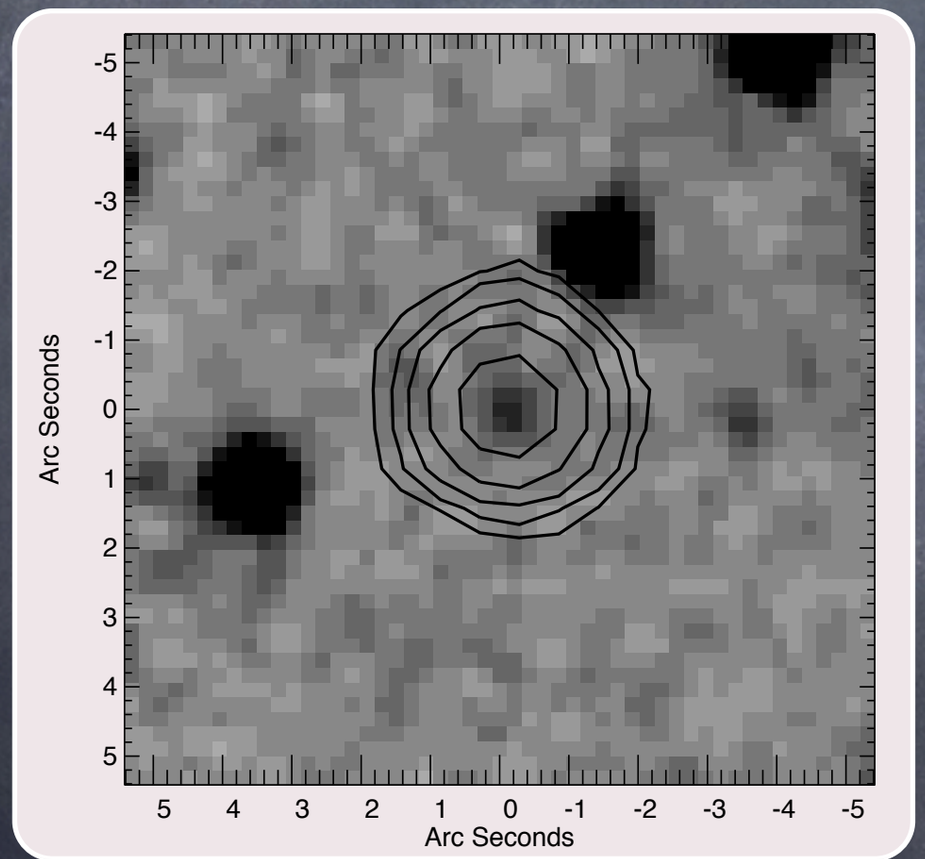

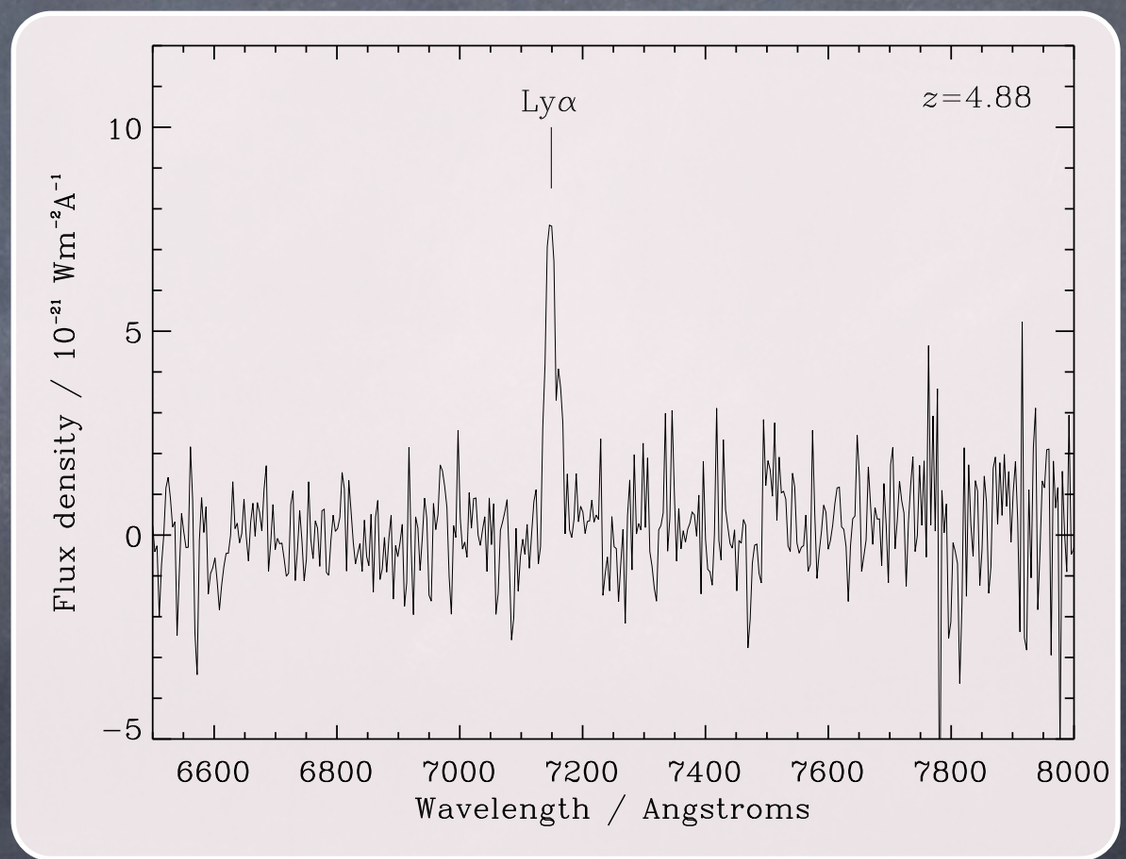

(a z=4.88 radio galaxy, Jarvis+09)

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3) Radio spectral index: Ultra Steep Spectrum sources ($\alpha \lesssim -1$, $S \propto \nu^{\alpha}$)

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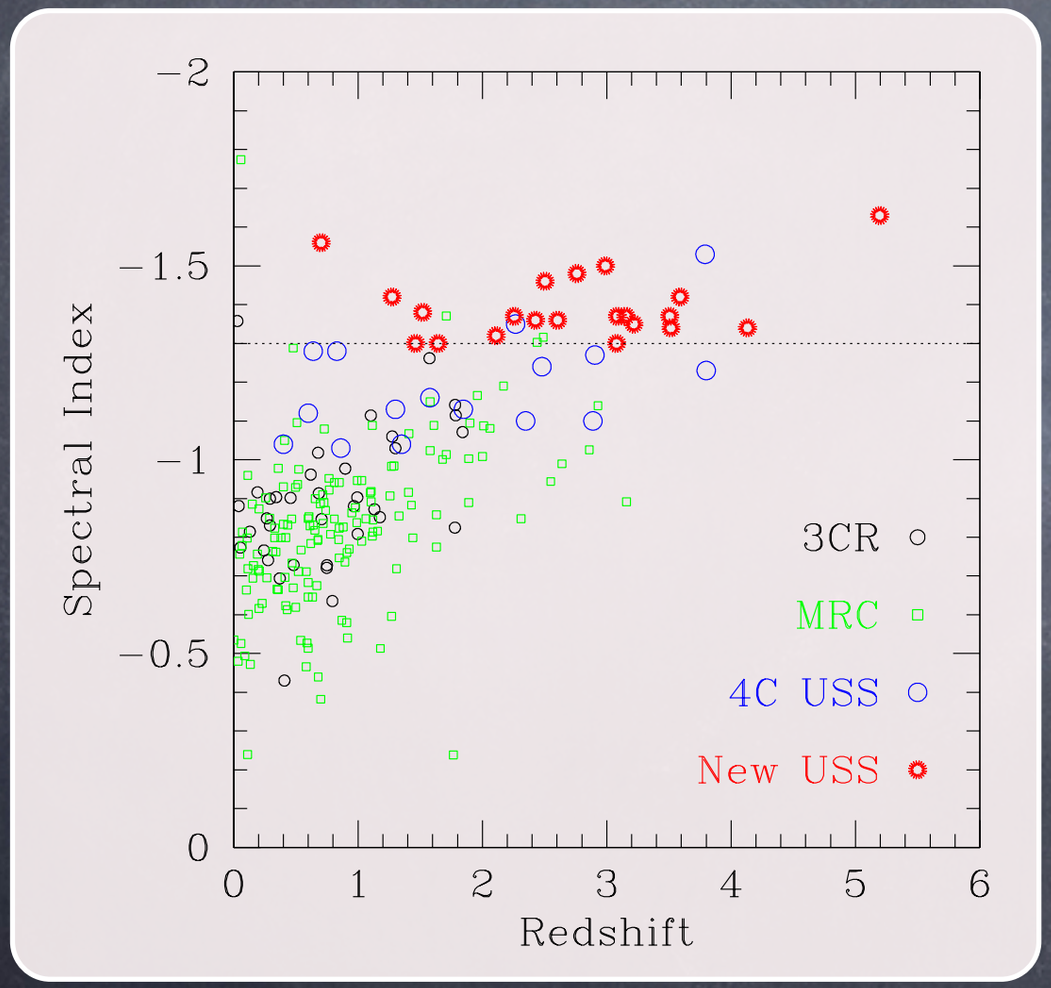
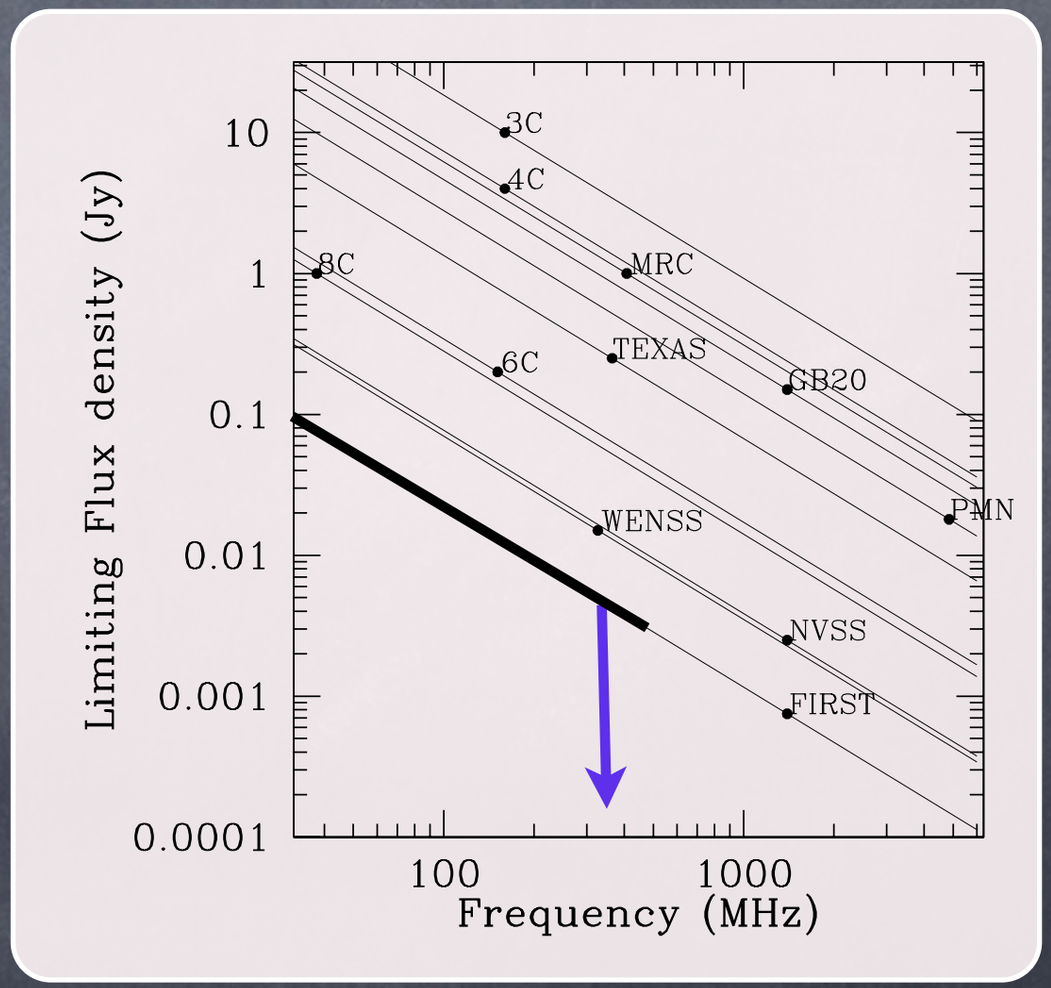




(De Breuck+2000)

USS radio sources in the Lockman Hole

- Extremely deep radio surveys available: 1.4 GHz (VLA) reaching 6 μJy rms and 610 MHz (GMRT) reaching 15 μJy rms; 0.6 sq deg (Ibar+09).

- Extensive multiwavelength coverage: includes IR coverage, in particular with Spitzer Extragalactic Representative Volume Survey (SERVS).

- Extensive spectroscopy coverage.

→ 58 (faint) USS sources (sub-mJy at radio freqs)

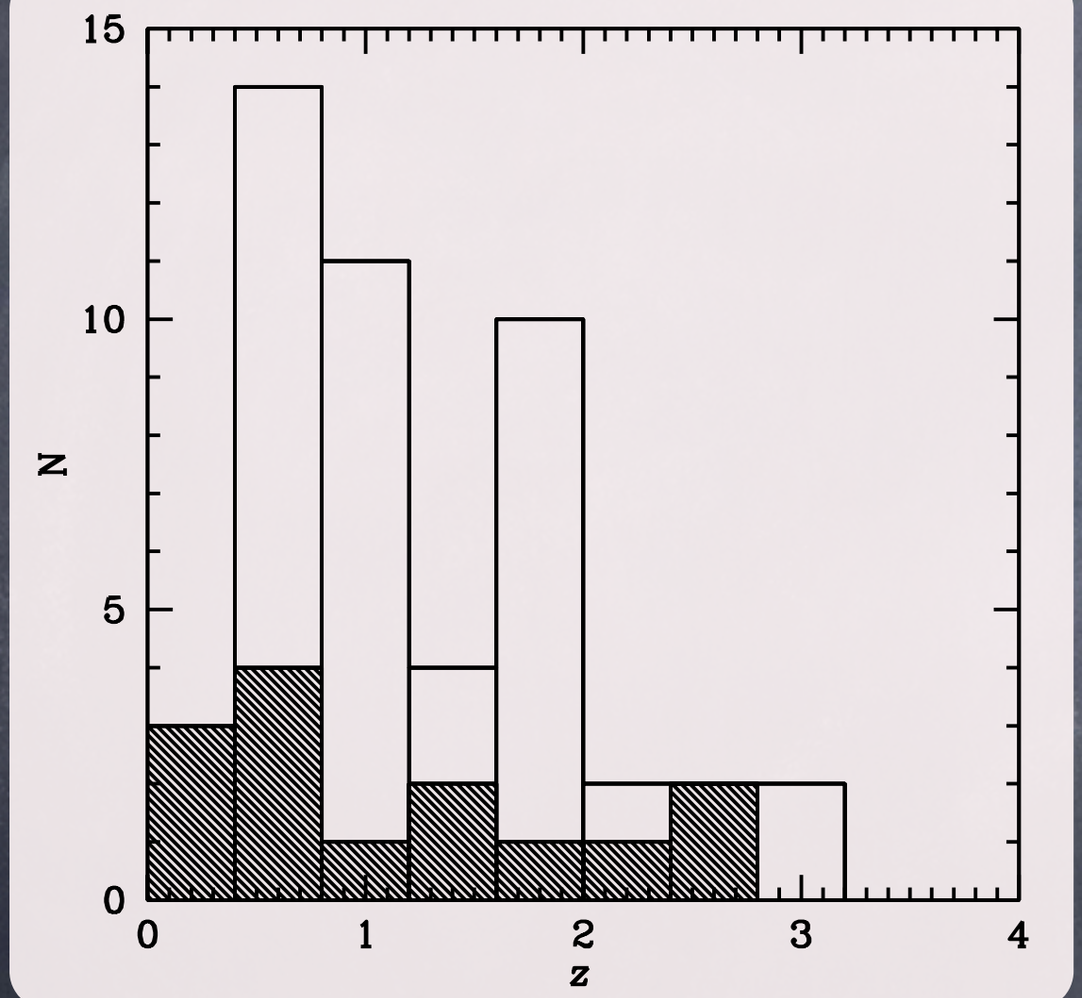
→ 48/58 reliable 3.6 μm IDs (to [3.6]~22-23 mag)

→ 14 sources with a spect-z; 34 further with a photo-z

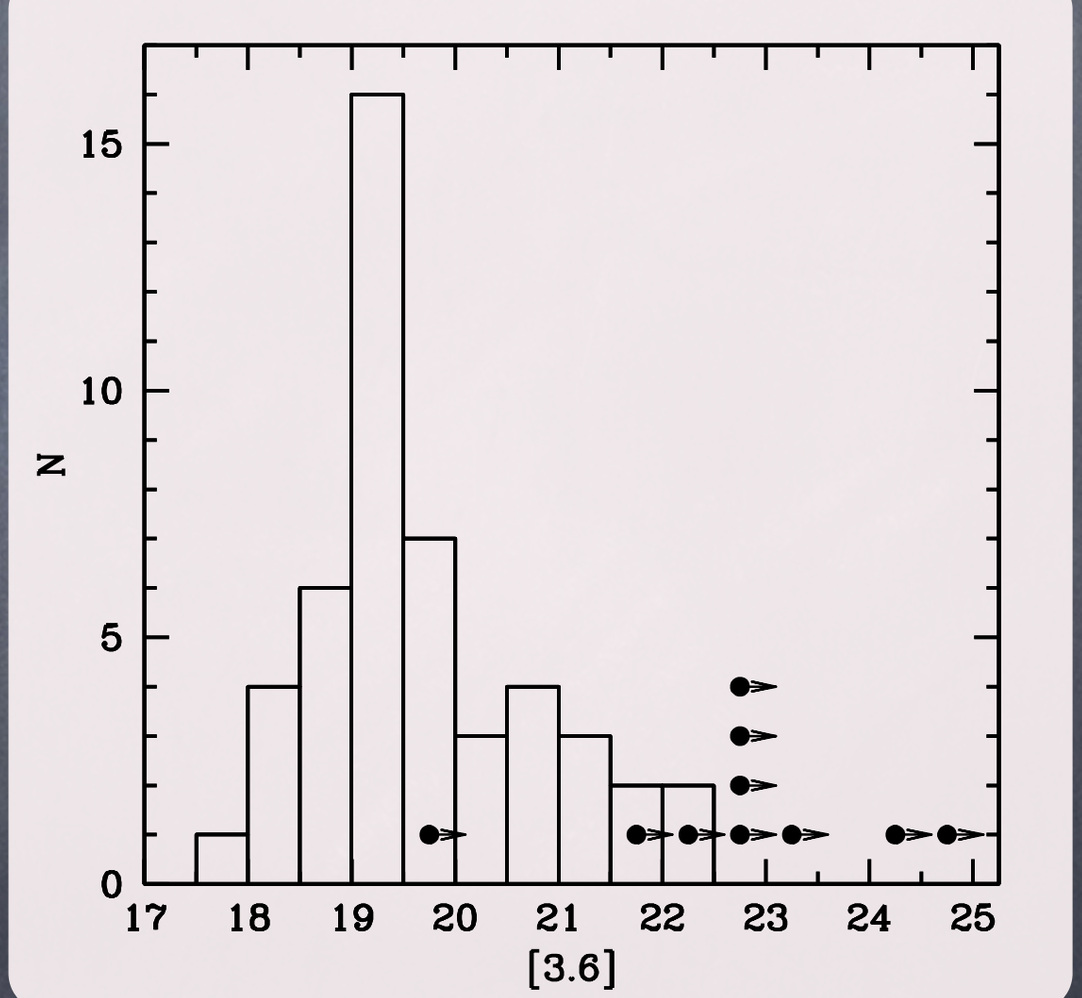
(Afonso+11)

USS radio sources in the Lockman Hole

USS Redshift Distribution:

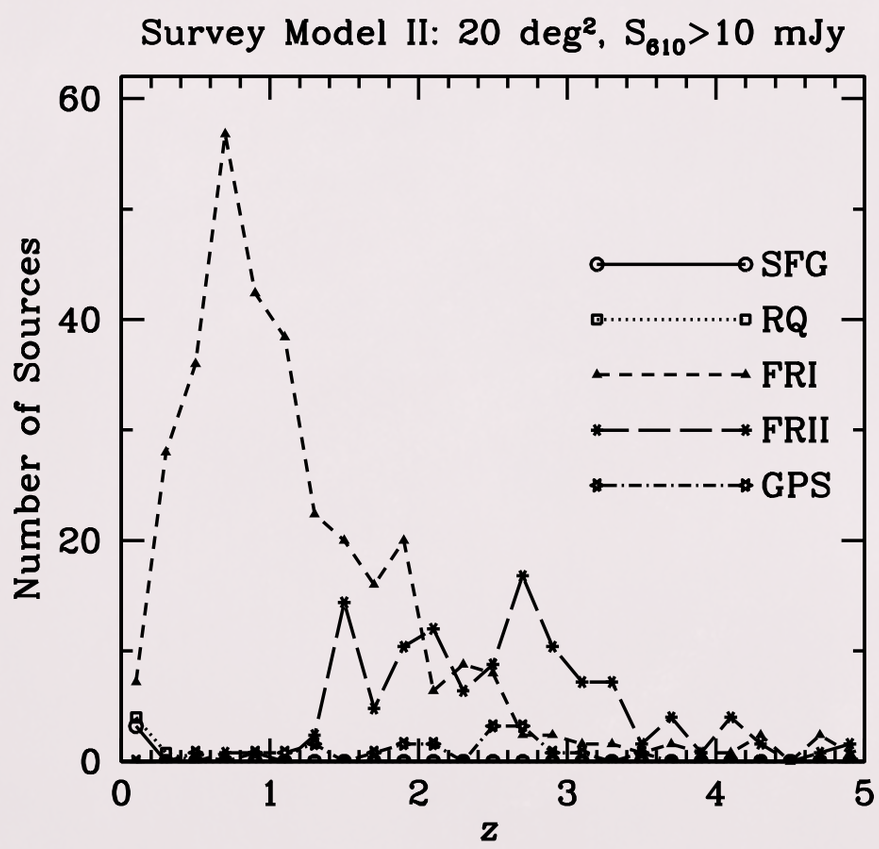


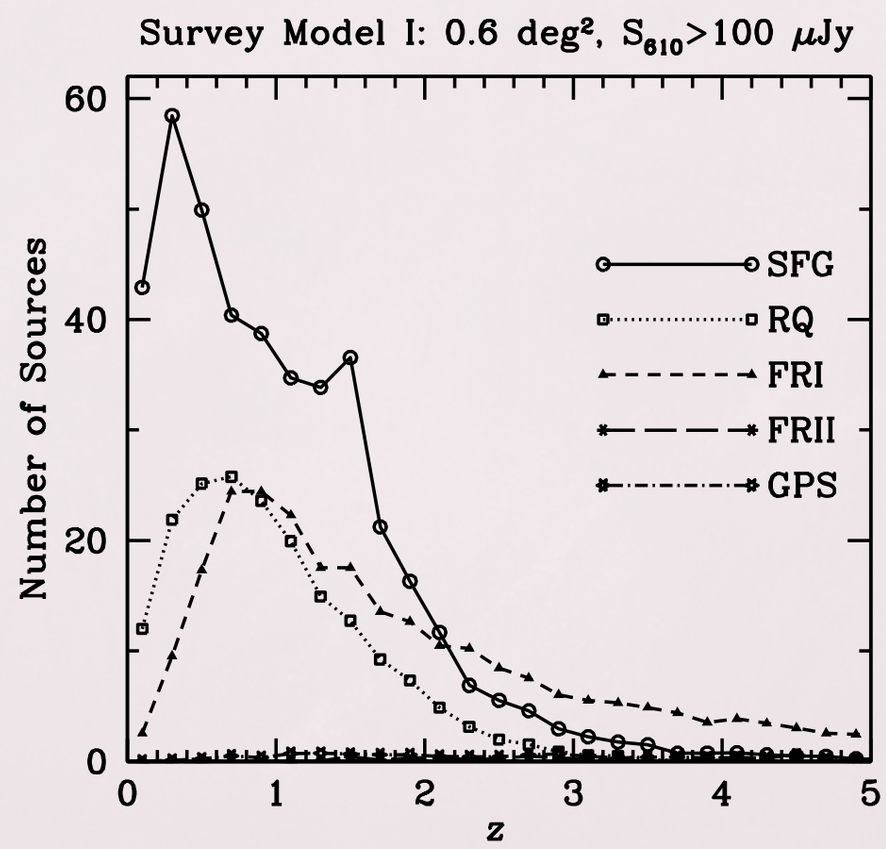
USS [3.6]-band Distribution:



USS radio sources in the Lockman Hole

SKADS Simulated Skies simulations (Wilman+08):





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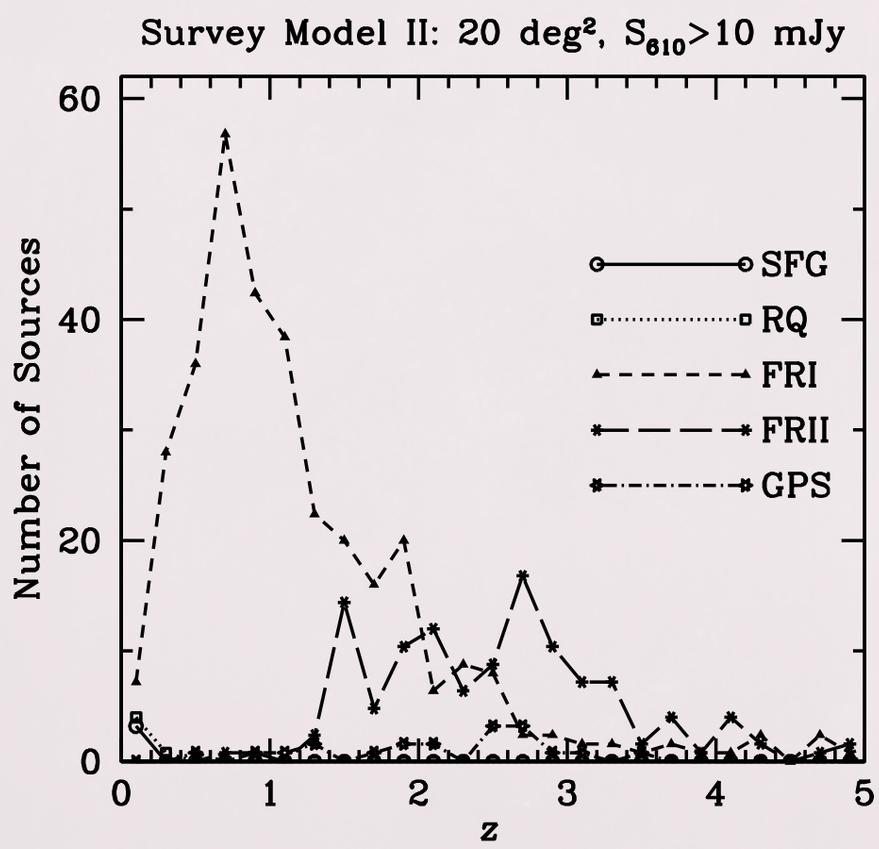
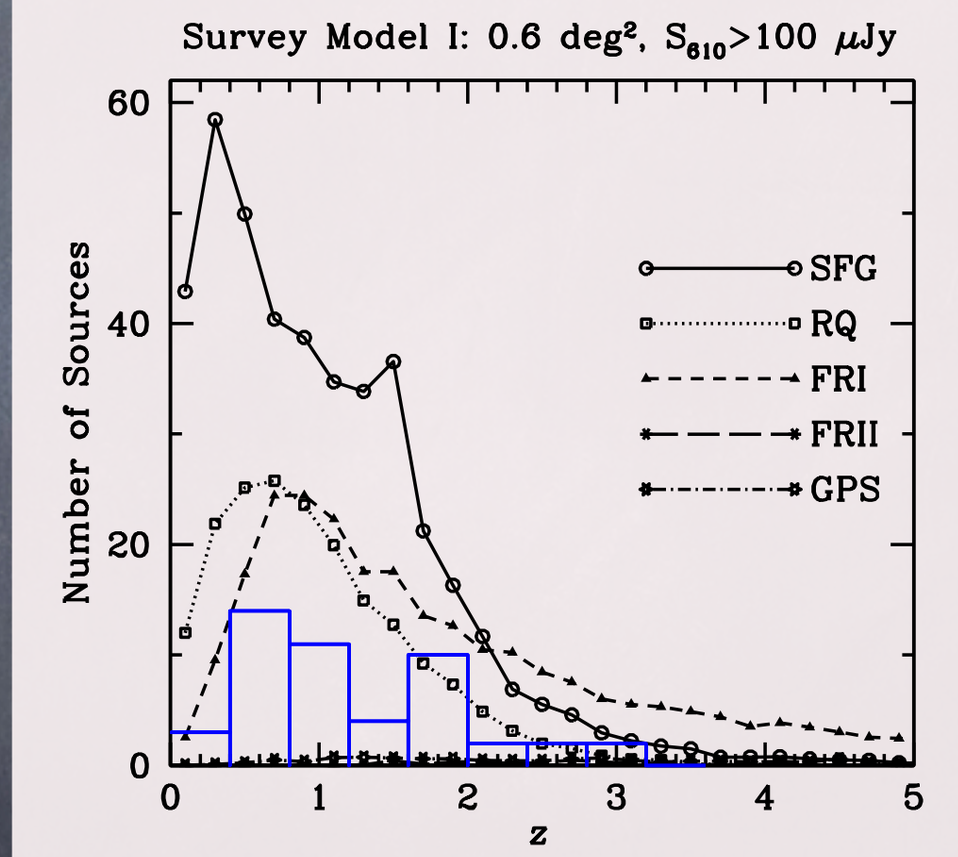
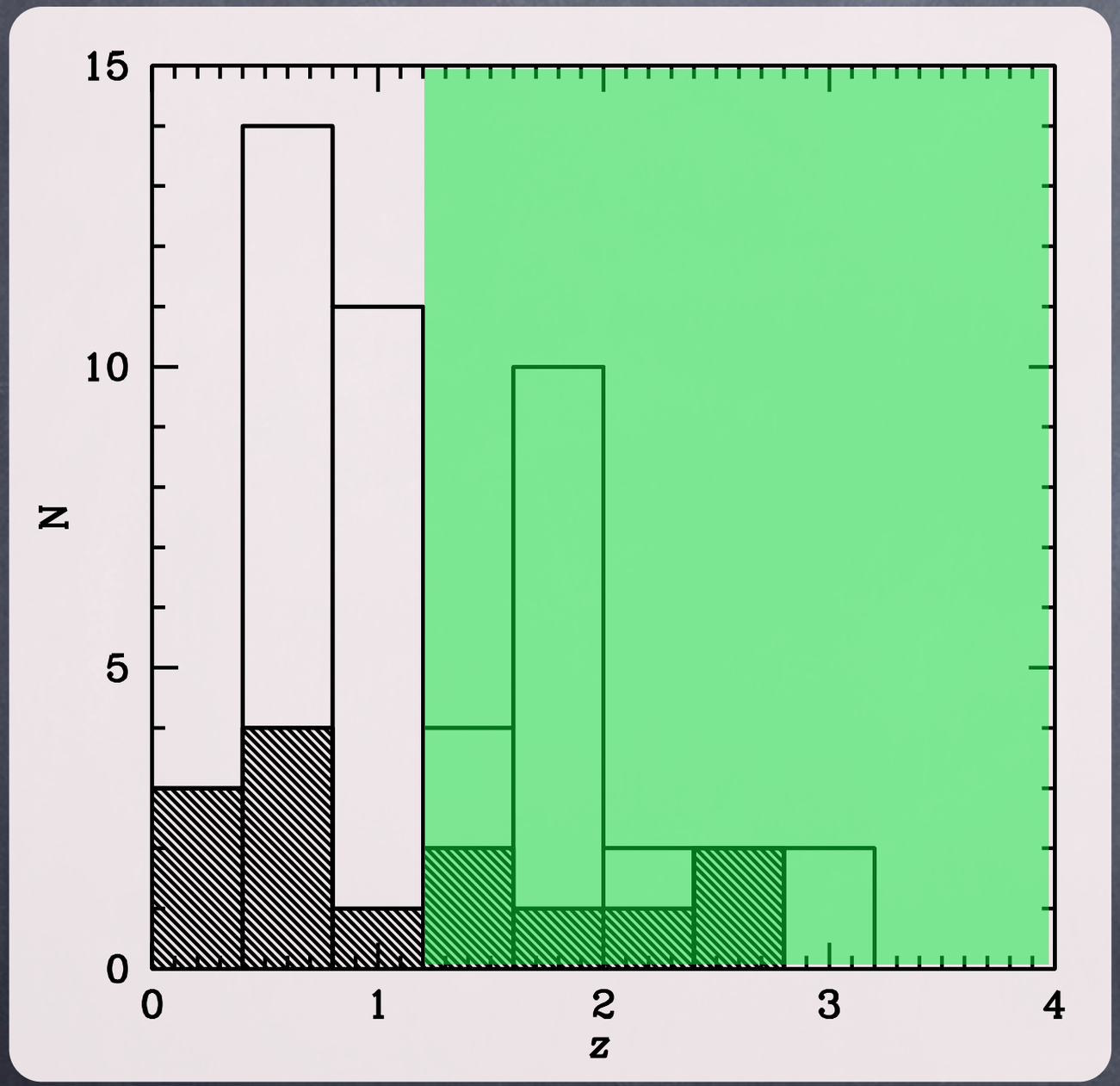




What about the environments?

Can faint USS sources still be used to trace proto-clusters?

What about the environments?

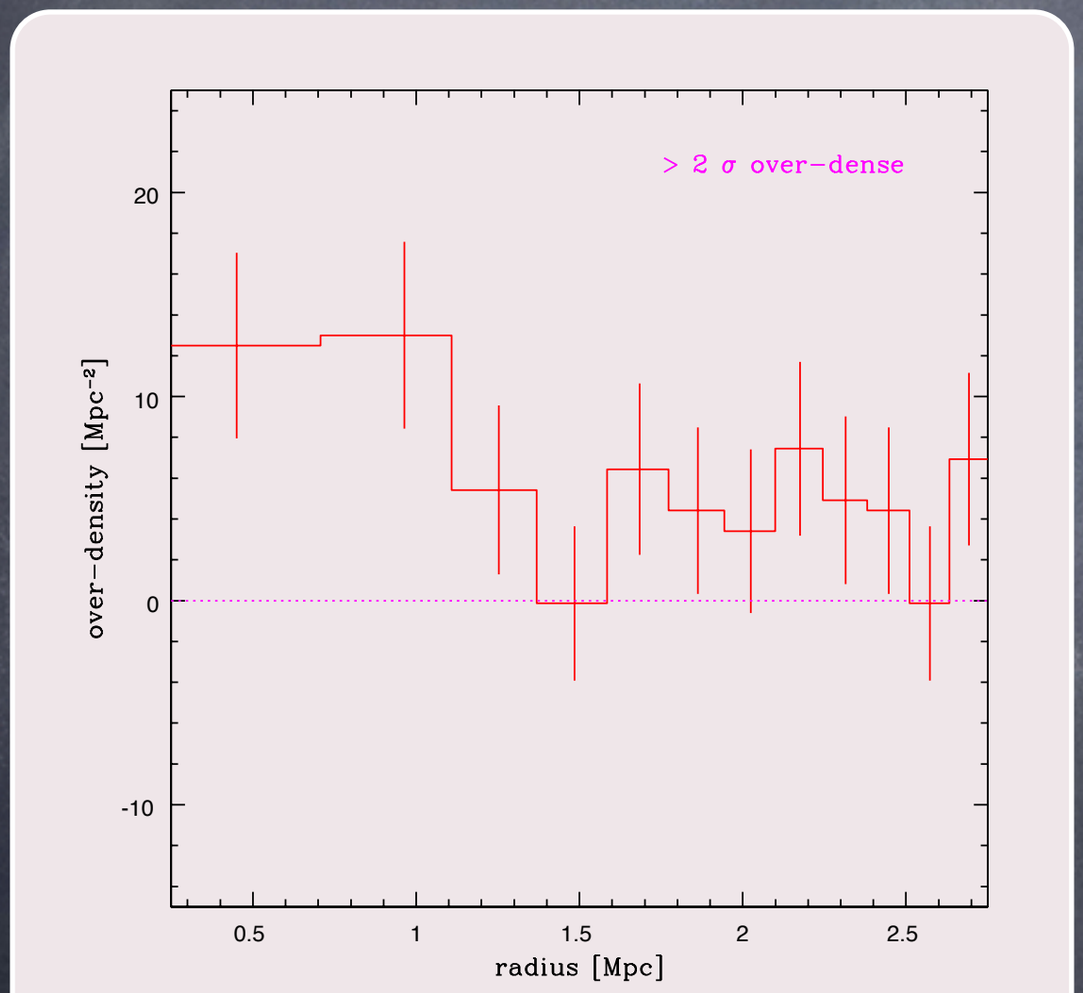


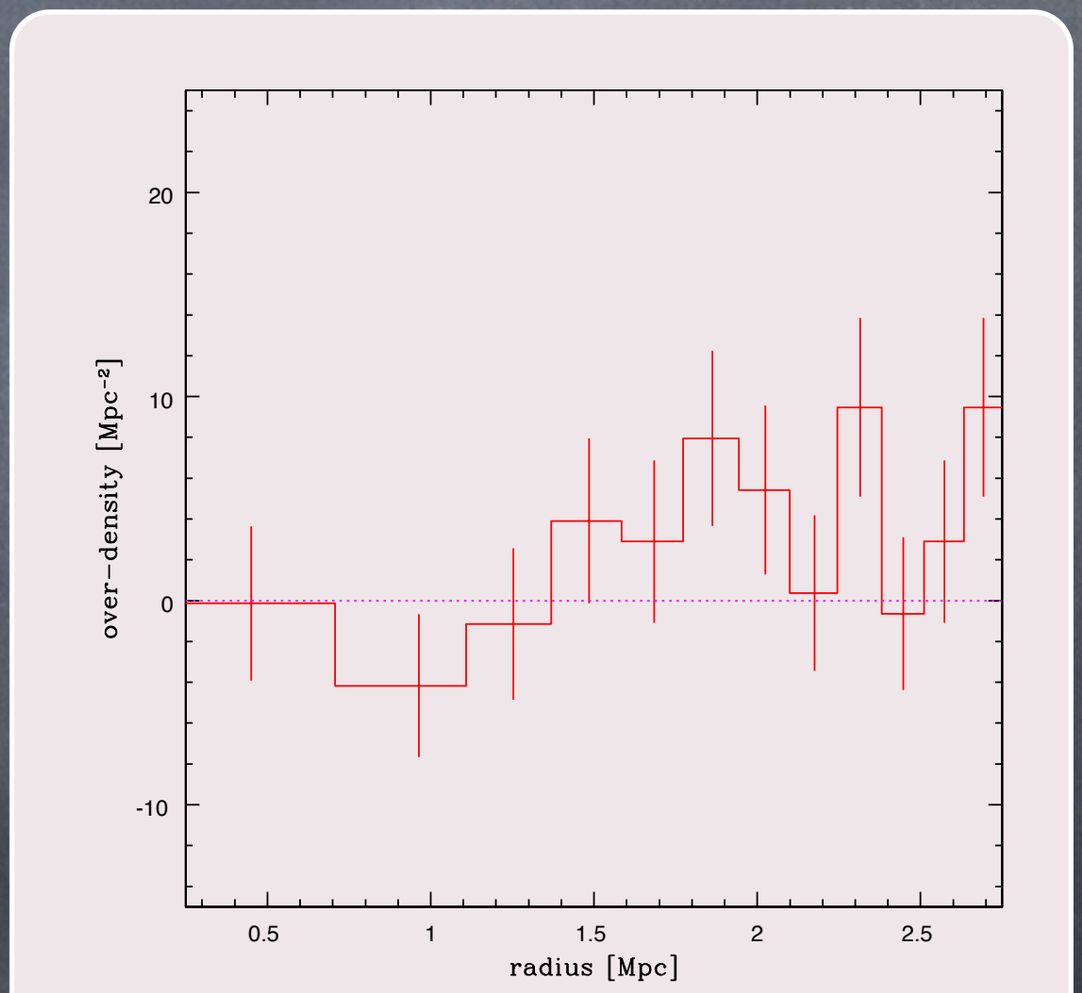
- **[3.6]-[4.5]>-0.1 mag suitable for z>1.2 (Papovich+08)**
- **Use [3.6]<22.5 (~m*+2 @ z~1.2-2) and m_r>22.5**
- **Detection of overdensities within 1′ (~0.5 Mpc @ 1<z<3)**

What about the environments?

- 5 (in 20) USS's in fields with overdensities (>2σ)

z=1.460(p), 1.677(s), 2.100(s), 2.285(p),2.560(s)





What about the environments?

- 5 (in 20) USS's in fields with overdensities (>2σ)

- Very similar to MIR environments of HzRGs - 11 (in 48) in overdense environments (Galametz+12)

- Interestingly, all 5 already detected at [3.6]<21.3 (but see Dominika's talk)

So...

Not only the USS criteria appears highly efficient to select high-z galaxies even at the faintest radio fluxes...

... but also the clustering properties seem similar to the traditional HzRG population.

The Future looks Bright

The Future looks ~~Bright~~ Faint

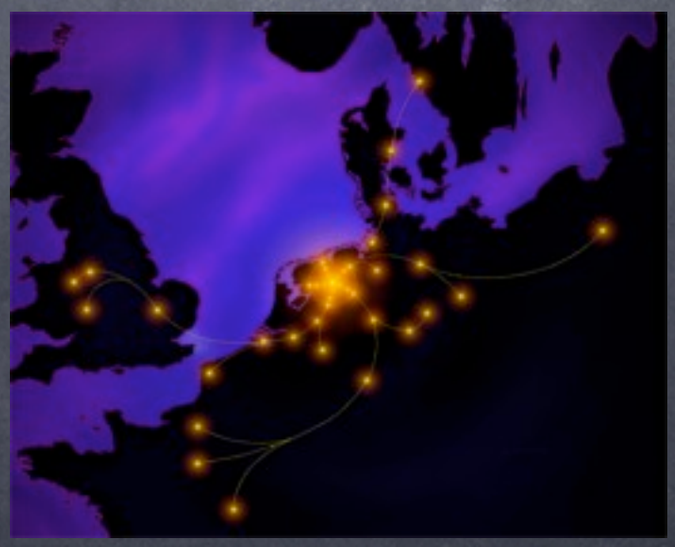
What today is an ultra deep (pencil-beam) observation will soon become full sky.

Evolutionary Map of the Universe (ASKAP); Norris+2011

Westerbork Observations of the Deep APERTIF Northern-Sky; Rottgering+11

=> FULL SKY @ 1.4GHz, 10-15” resolution, 10 µJy rms (2013++)

Lower frequencies even sooner...



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http://caaul.oal.ul.pt

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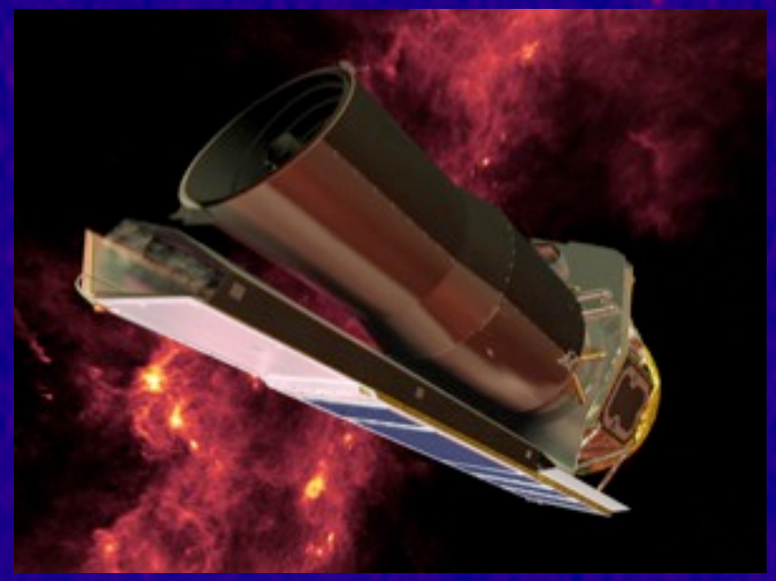

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