Low redshift quasars in the SDSS Stripe 82: Local environments

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Karhunen, K. et al. 2014, MNRAS, 441, 1802

Quasar environments – what's the big deal?

- What triggers the activity?
  - Internal causes?
  - External causes?
- Galaxy interactions/mergers more common in denser areas
  - → More quasars in dense areas?

Quasar environments

- Earlier studies show mixed results:
  - Smith et al (2000) found quasar environments consistent with normal galaxies
  - Wold et al (2001) found a galaxy excess within 0.5 Mpc radius
- In general quasars thought to occur in ”denser” areas

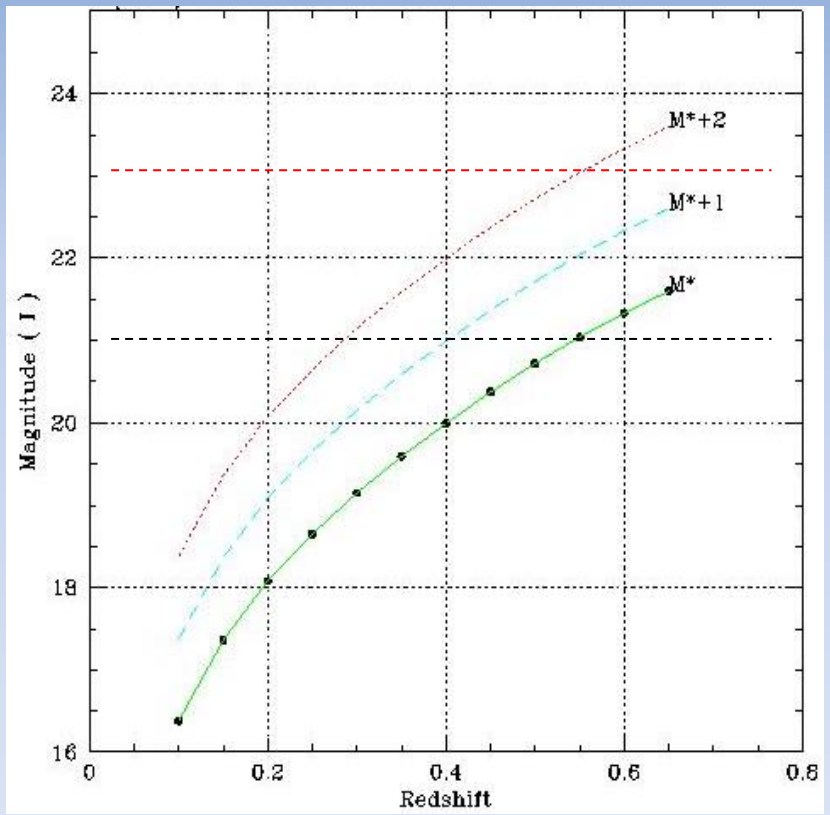
- No dependence of density on z at low redshifts
- More luminous quasars have larger overdensities at < 100 kpc radius, but the difference disappears at ~Mpc scales (Strand et al. 2008)
- Effects of radio luminosity still unclear(?)

- Early studies had mainly small sample sizes of few tens of objects, and no control samples (or poorly matched ones)
- More recent studies (e.g. Serber et al 2006, Strand et al. (2008)) have taken advantage of the larger samples provided by surveys like the SDSS → several thousand objects

What is there left to do?

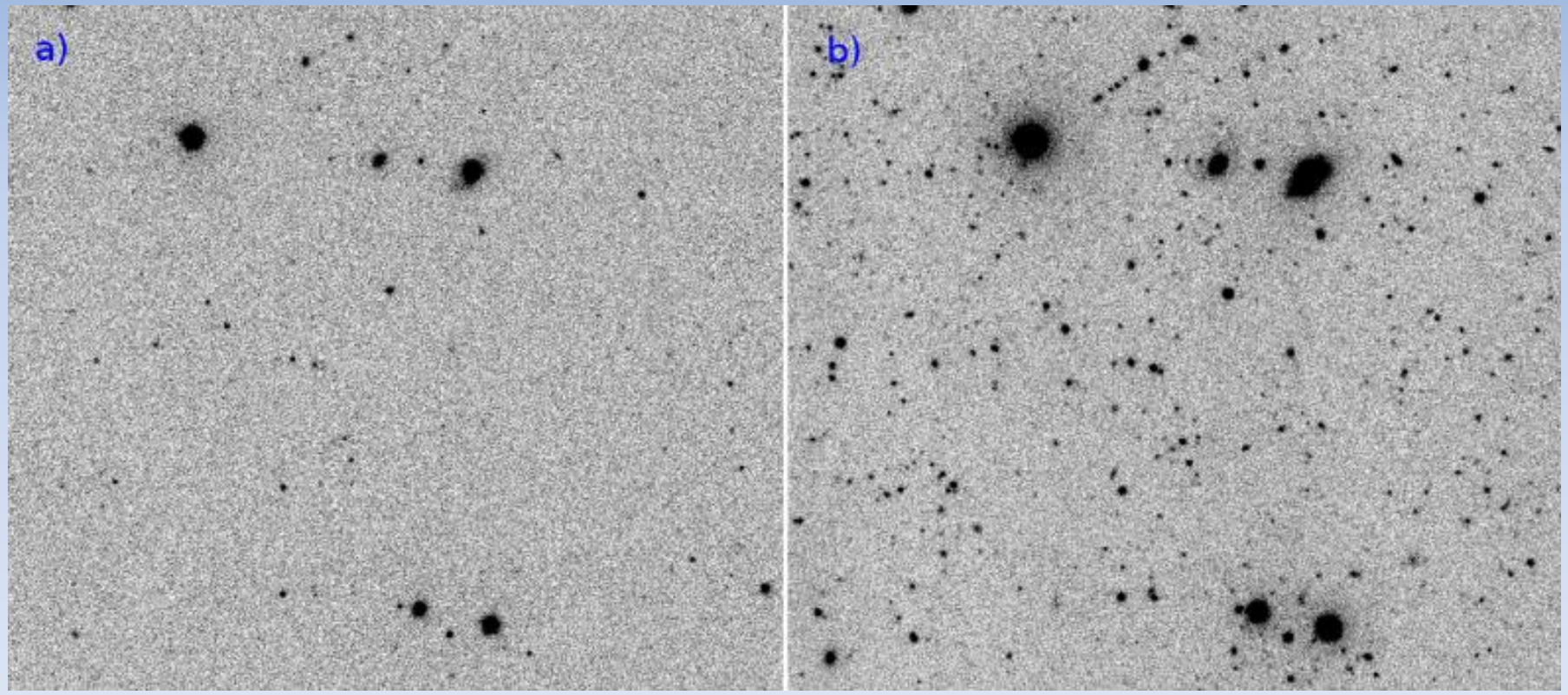
- For environment studies, SDSS is used to get large samples, but the images are ”too shallow” to get the complete picture
  - Standard SDSS data can reach a depth of m_i ~21

- Additionally, for studies on environments, important to have a control sample of non-active galaxies with similar properties to the QSO sample
- Previous studies generally only match samples based on redshift



Stripe 82

- Covers a total area of ~270 deg^2 between -1.25 < Dec < 1.25 and 310 < RA < 59
- Each piece of the area imaged ~80 times
- Coadded images ~2 magnitudes deeper



Choosing the sample

- Redshift: $0.1 < z < 0.5$

- Full QSO sample (FQS):
  - Selected from SDSS – QSO Catalogue (Schneider et al. 2010)
  - 416 QSOs: $\langle z \rangle = 0.39 \pm 0.08$, $\langle M_{i,QSO} \rangle = -22.68 \pm 0.62$
  - Dominated by RQQ (only 24 RLQ)

- Full control galaxy sample (FCGS):
  - Selected a similar sized sample of ”passive” galaxies with a distribution of redshifts close to that of the QSOs
  - 580 galaxies: $\langle z \rangle = 0.38 \pm 0.08$, $\langle M_i \rangle = -22.22 \pm 0.77$

Choosing the sample

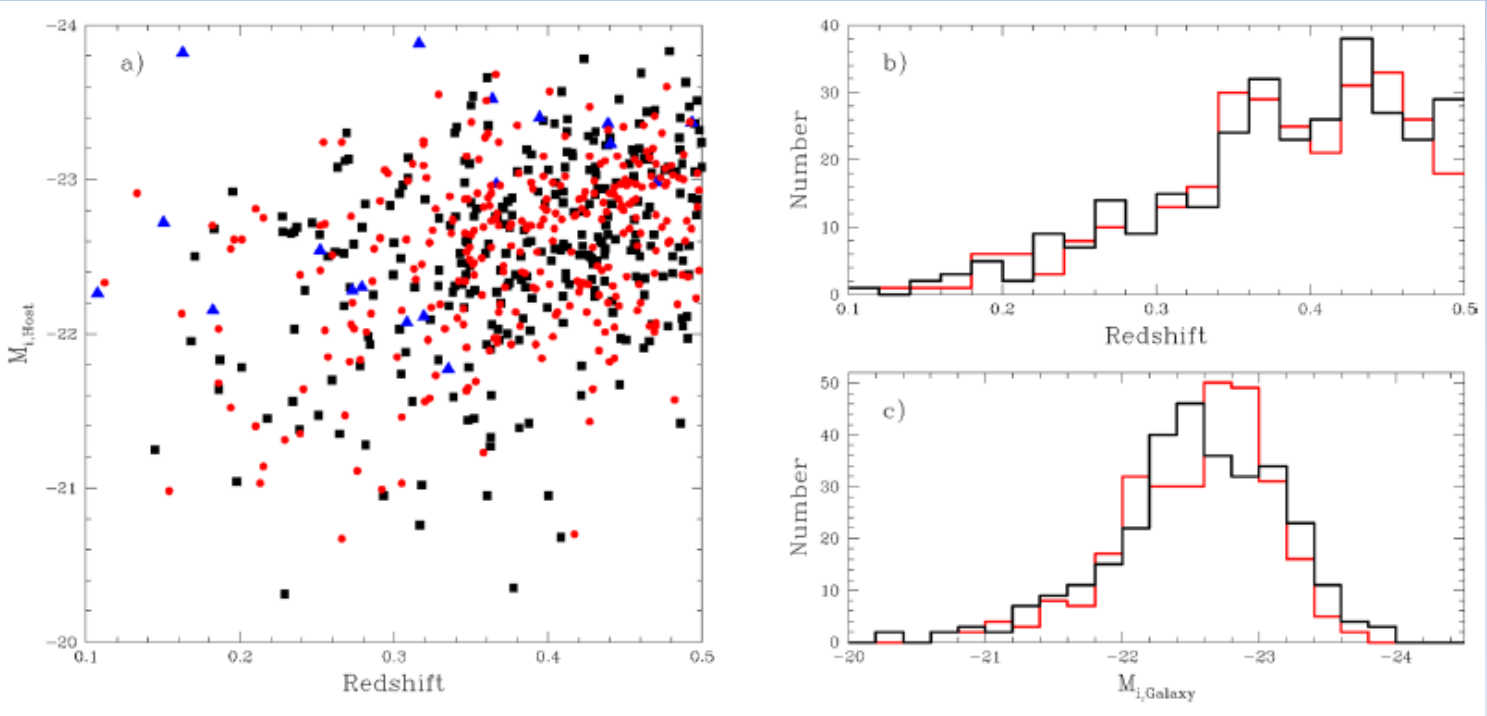
- Selected a sample of 302 QSOs resolved by Falomo et al. (2014)

  → RQS: $\langle z \rangle = 0.38 \pm 0.08$, $\langle M_{i,host} \rangle = -22.54 \pm 0.63$

- Selected a subsample from the FCGS, matching the luminosities of the non-active galaxies to those of the resolved QSO hosts

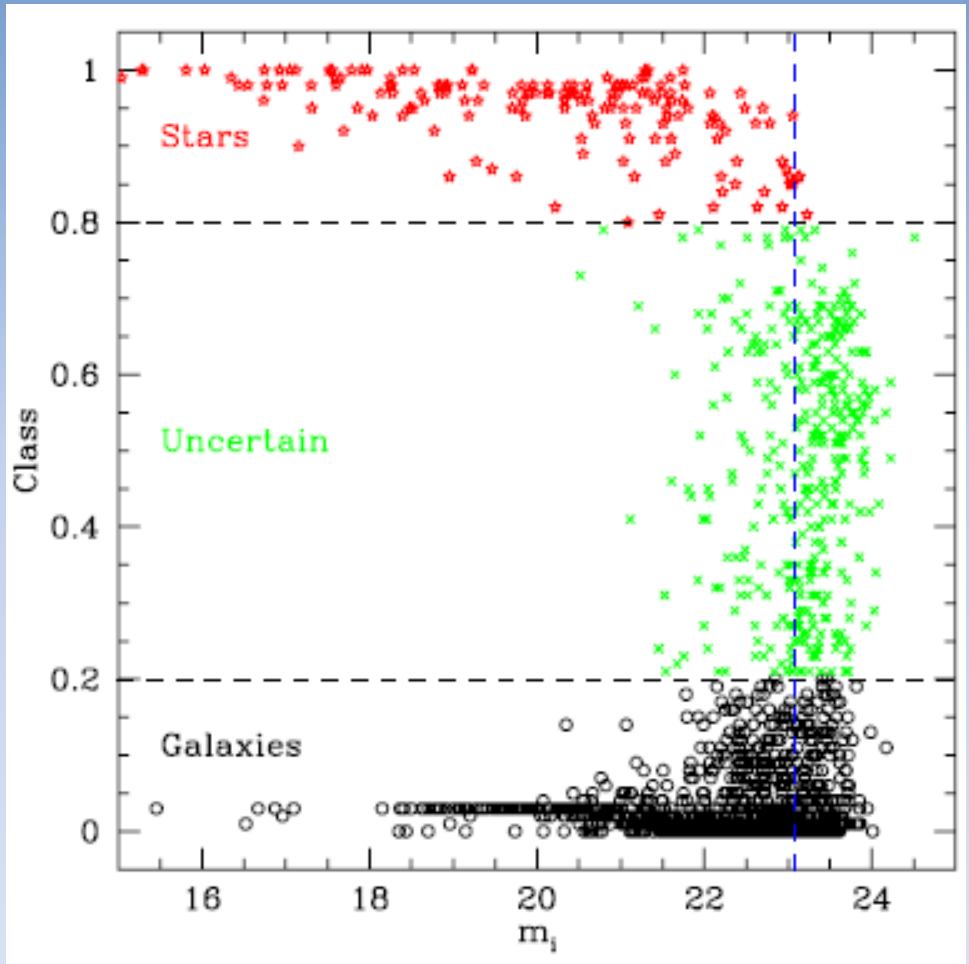
  → MCGS of 288 Galaxies

  $\langle z \rangle = 0.38 \pm 0.08$, $\langle M_i \rangle = -22.53 \pm 0.55$



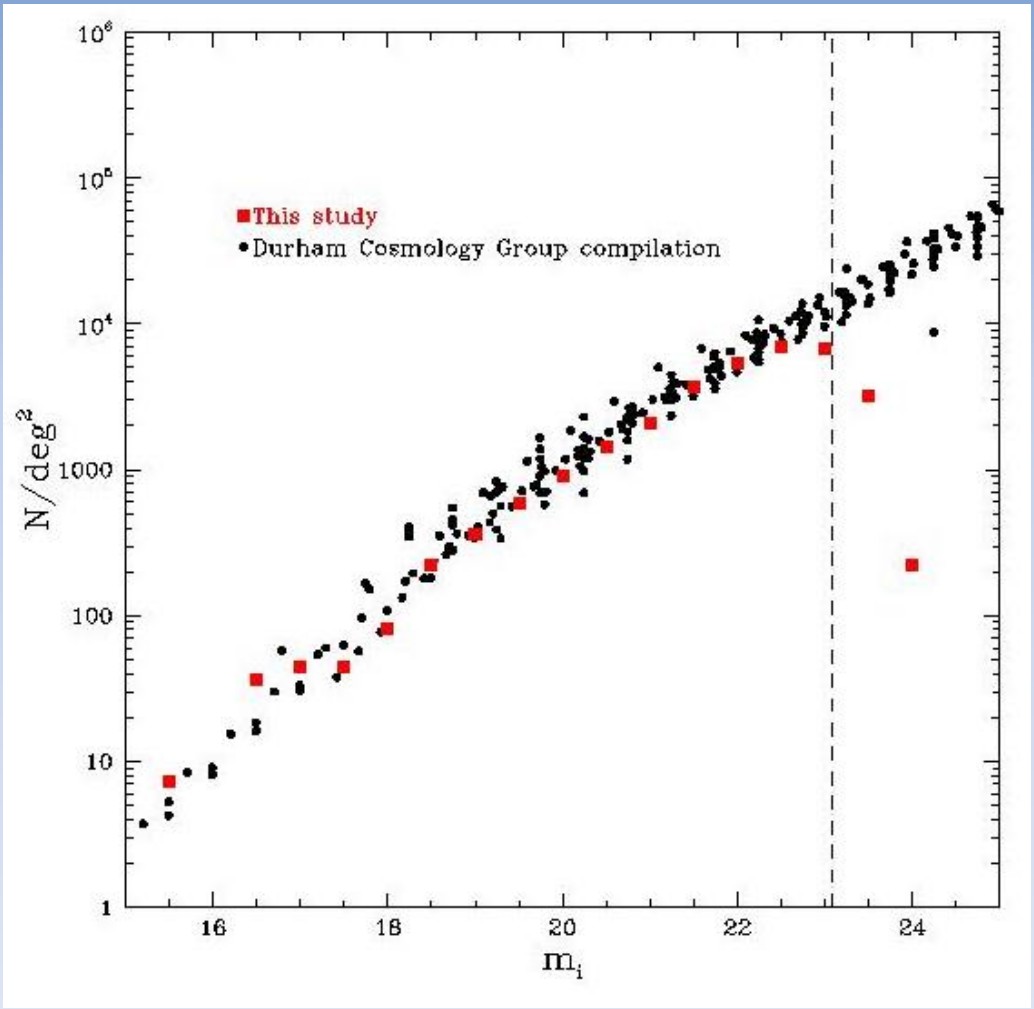
Studying the environments - Galaxy counting

- Need to count galaxies
  - i) around the QSO and
  - ii) in the background
- For this, need 4 images per object:
  - 1 ”target” frame
  - 3 ”environment” frames
- Object detection & classification done with Source Extractor
- Background:
  - Average density calculated from 30 randomly chosen locations in the field



How deep can we actually go?

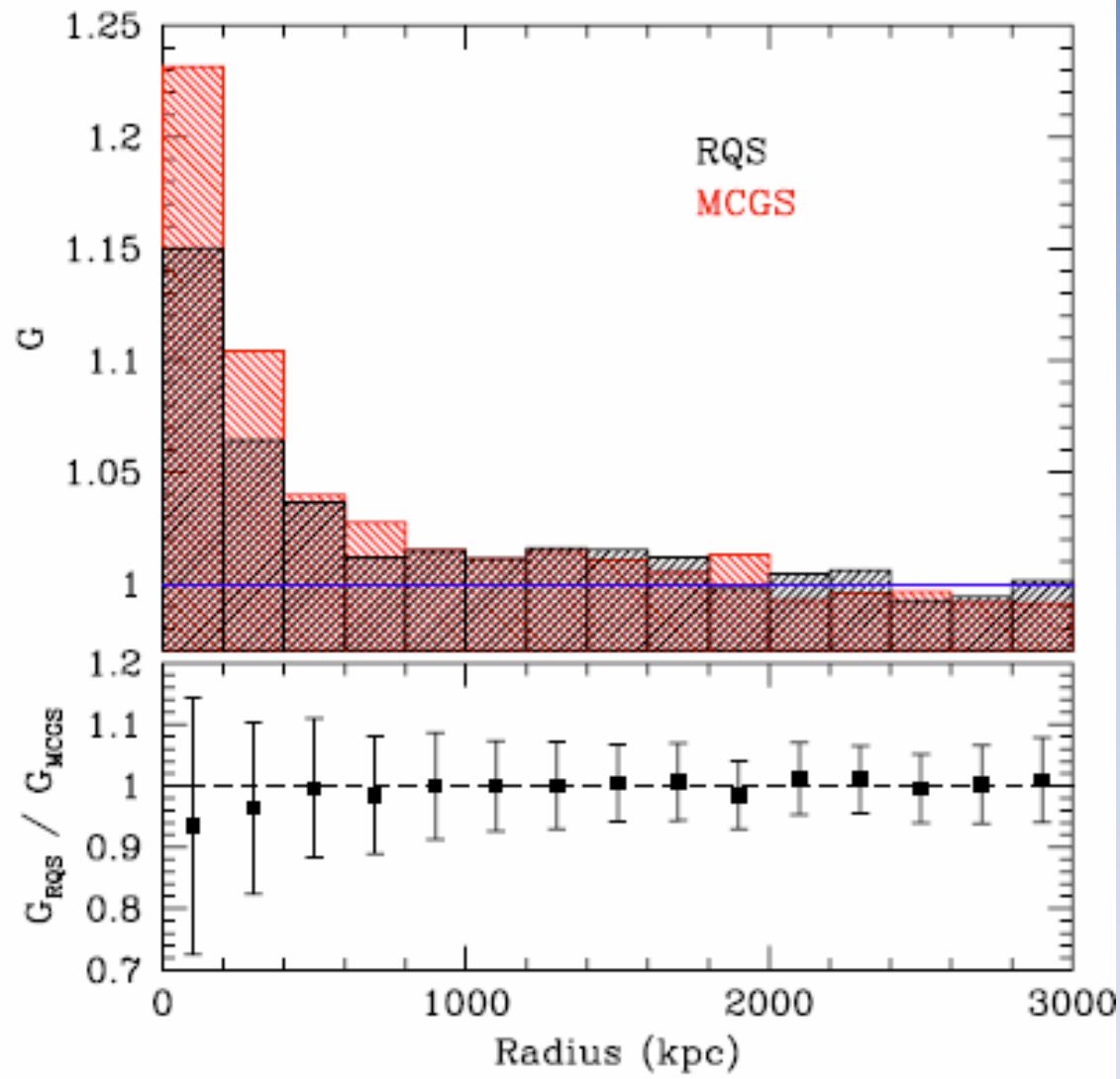
- To study completeness, compare measured galaxy counts to those expected
  - Compilation of published counts by Durham Cosmology Group*



- Magnitude limit set at 50% completeness
- $\langle m_{lim} \rangle = 22.81 \pm 0.22$

*http://star-www.dur.ac.uk/~nm/pubhtml/counts/counts.html

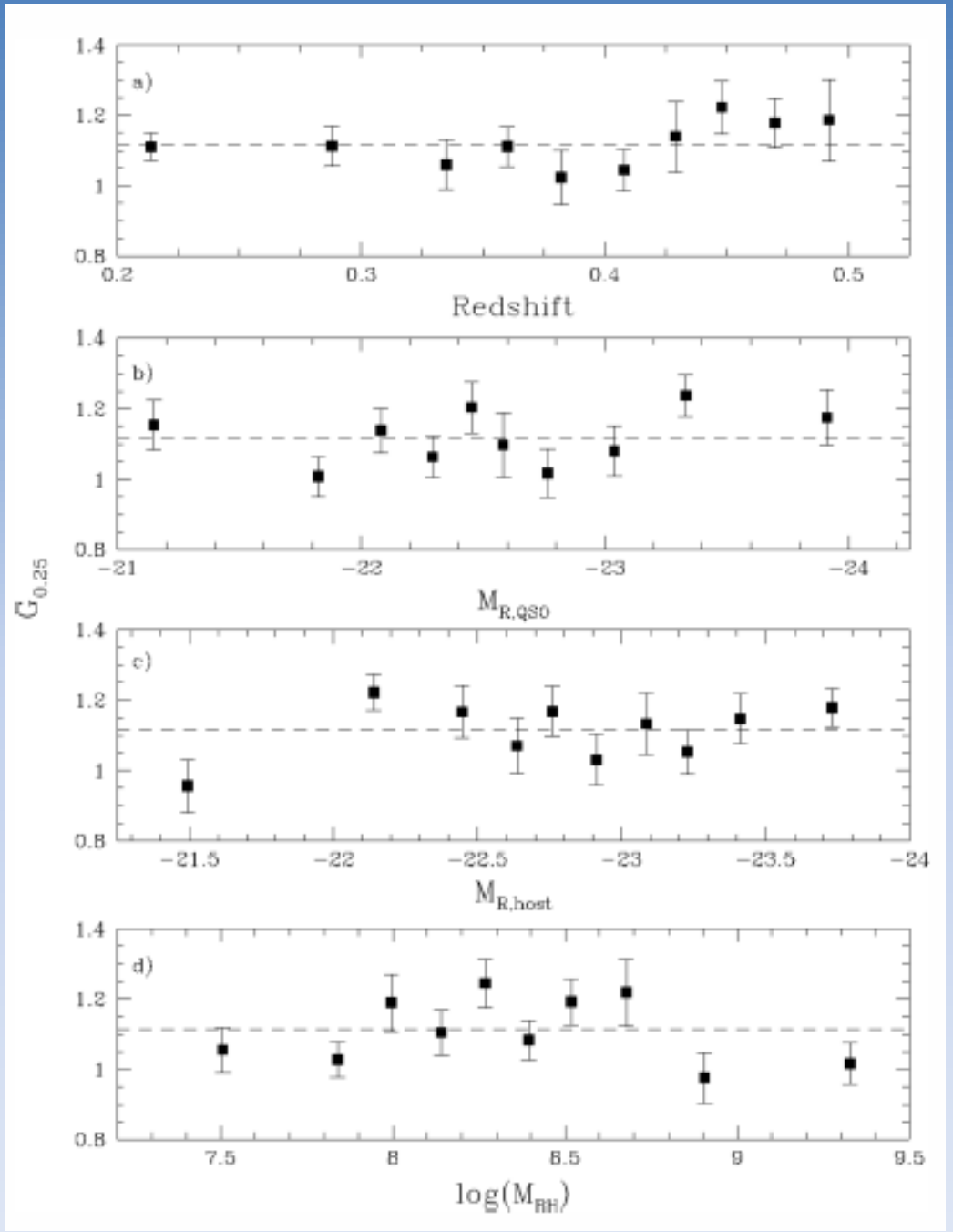
Environmental overdensity



- Overdensity, G, defined as N_{env}/N_{bg}
- G falls with radius for both samples
- No statistically significant difference between samples

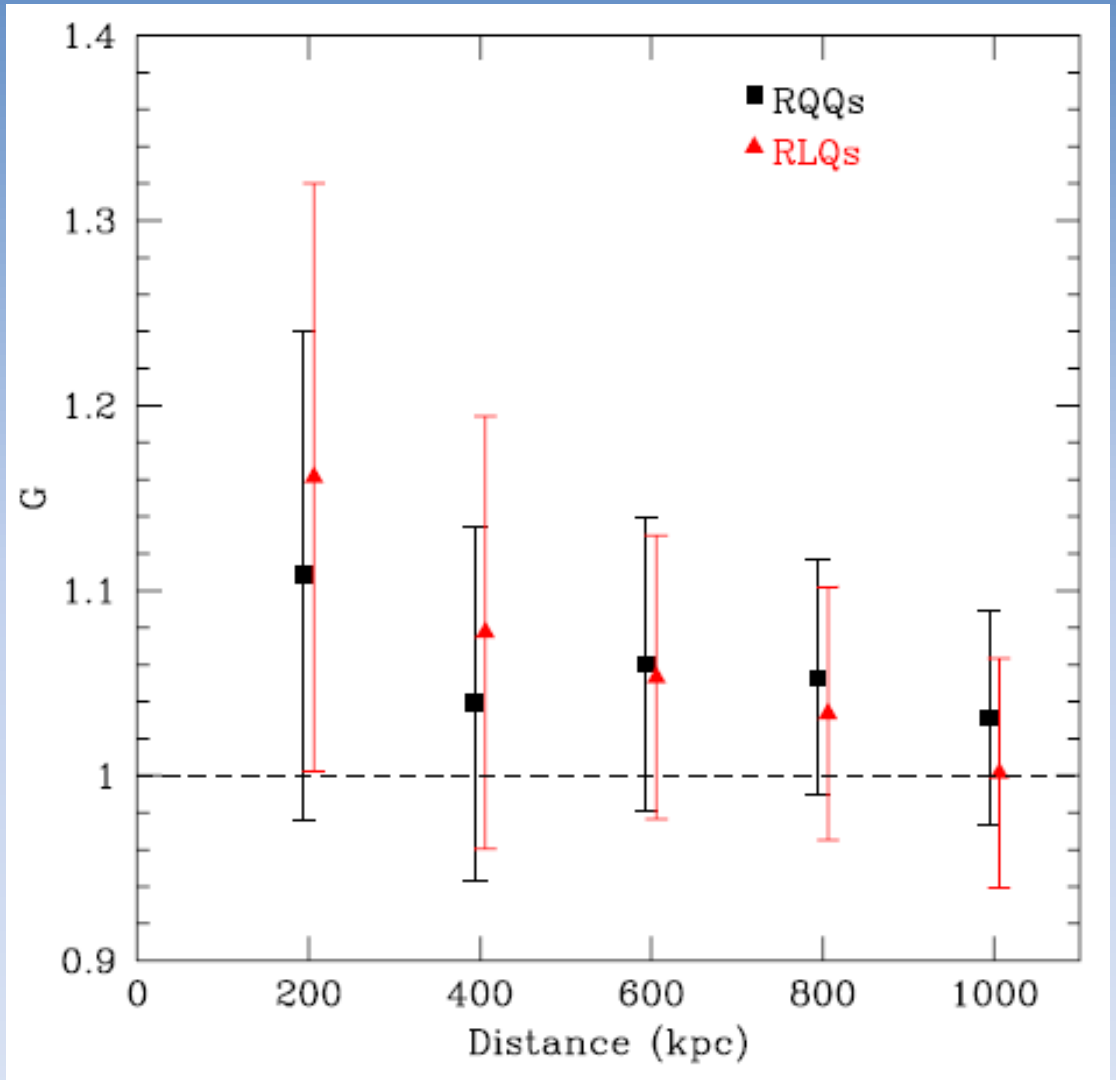
- Define $G_{0.25}$ parameter: overdensity within a distance of 0.25 Mpc

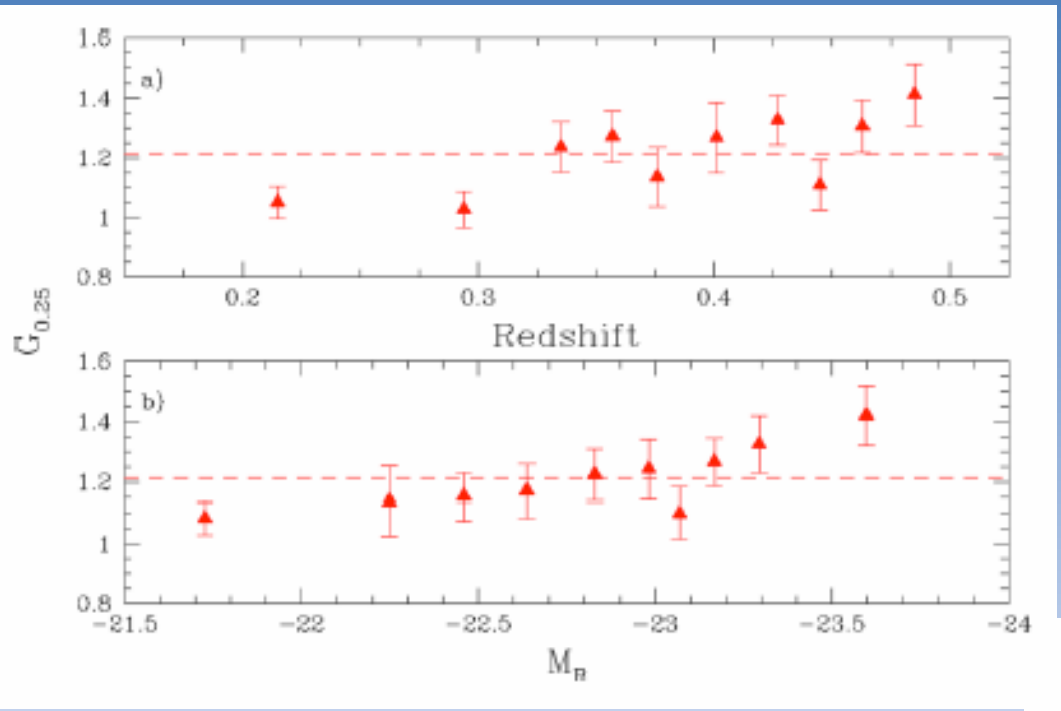
- No dependence on overdensity found for any studied parameter (redshift, luminosity of the quasar or its host galaxy, mass of the central black hole)



- Additionally, no difference was found between RLQs and RQQs

- BUT:
  - Large uncertainties
  - Radio luminosity of our ”RLQs” is low

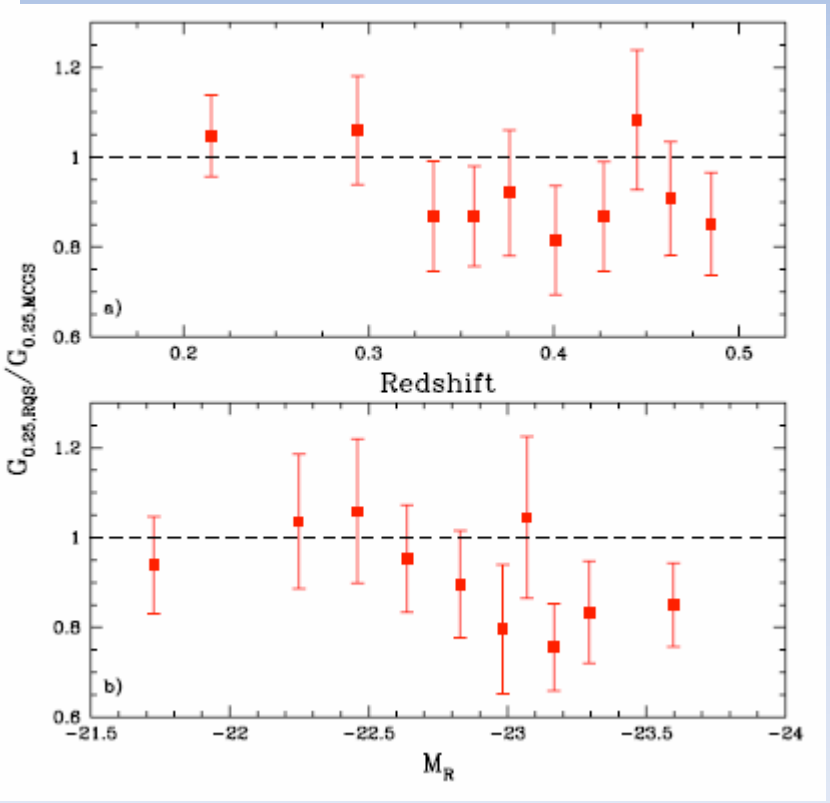




- For control sample, trend found for both redshift and galaxy luminosity
- The two trends appear to be independent

Overdensities of quasar and control samples still consistent with each another!

Environment not as important for fueling and triggering quasar activity?



Summary

- QSO environments similar to those of regular galaxies
- Overdensity around QSOs (and control galaxies) largest at small radii ($r < 200$ kpc)
- No dependence on redshift, quasar host/nucleus luminosity, black hole mass or radio luminosity found
- The link between quasar activity and the environment less important than believed