Exploring the Quasar Population in the Near-Infrared

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Outline:

- Motivation
- Ingredients
- Quasar host galaxy magnitudes
- Results
- Summary

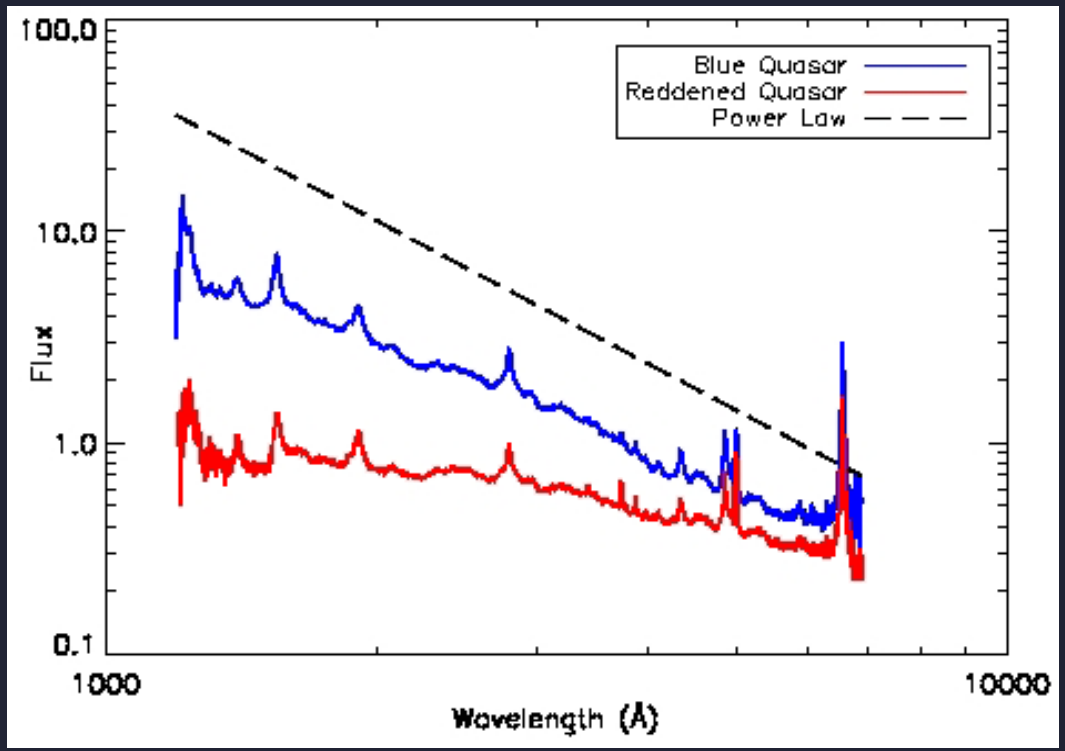
Motivation:

- More quasar surveys?
- Observations range from radio to X-ray
  - Important question: do all observations agree?

Reddened Quasars:

- Dust-obscuration of shorter, optical wavelengths

  - Definitely exist, but how many compared to unobscured?



Goal:

- Make predictions for NIR based on unobscured quasar population at blue wavelengths
- Provide context for existing and new observations (e.g. 2MASS, UKIDSS)
- Assist planning of future surveys focussed on red objects

Ingredients:

- Quasar Luminosity Function (QLF)
- Quasar Spectral Energy Distribution (SED)
- Quasar Host Galaxy type, distribution

QLF:

- From 2df+6df Quasar Redshift Surveys
- $16<m_{bJ}<20.85$, $0.4<z<2.1$
  - Fair representation of blue, unobscured quasar population

$$\Phi(M,z)=\frac{\Phi(M^*)}{10^{0.4(\alpha+1)(M-M^*)}+10^{0.4(\beta+1)(M-M^*)}}$$

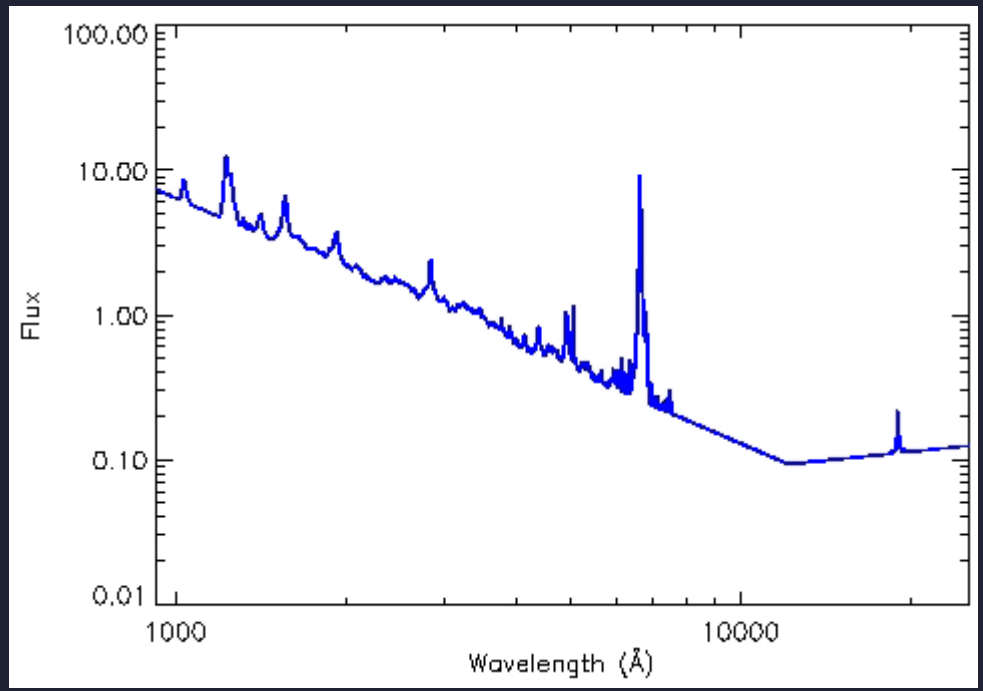
Quasar SED:

- Underlying power-law continuum with emission line spectrum:

$$F(\nu)\propto\nu^{\alpha}$$

with $\alpha=-0.3$ for $912\le\lambda\le12000$A

and $\alpha=-2.4$ for $12000\le\lambda\le25000$A

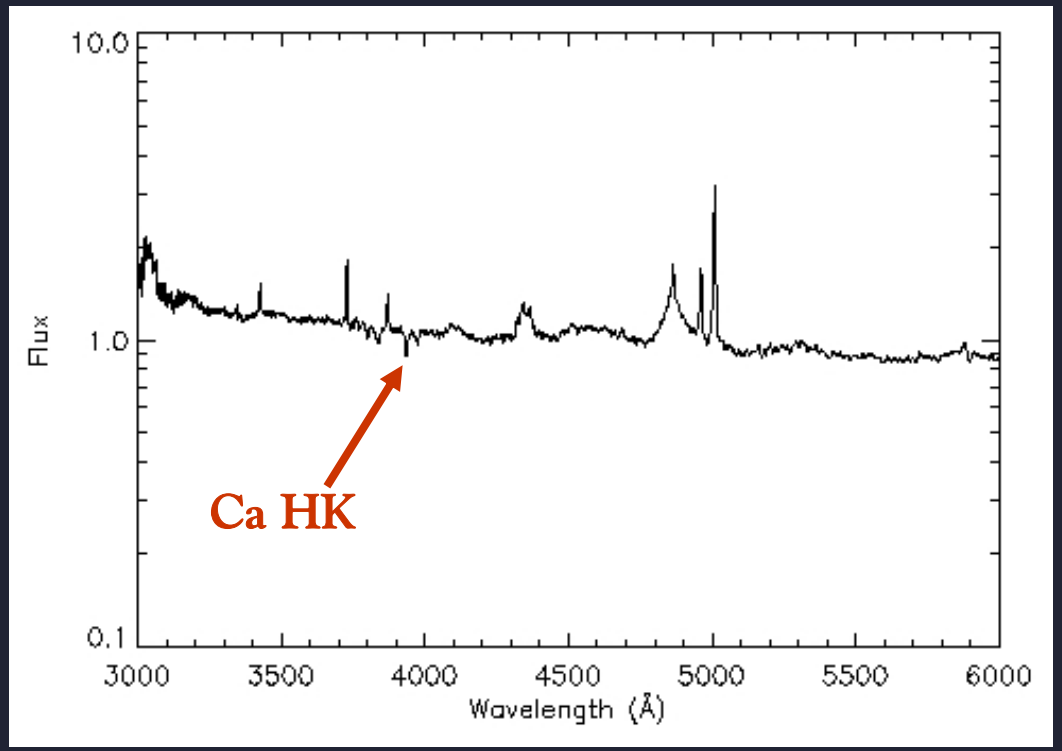


Quasar Host Galaxies:

- Quasars are located in the centres of galaxies
- Quasars much brighter than host galaxies at shorter wavelengths, but galaxies will be important in NIR flux-limited samples
- Want to add host galaxy flux to that of quasars by hand in simulations
- Need to determine galaxy type and relationship between M_{gal} and M_{qso}, if there is one
- Many imaging studies, all find hosts of bright quasars are massive ellipticals

Galaxy Fraction from Composite Spectra:

- Significant starlight from host galaxies appearing in quasar spectra
- Use stellar absorption lines in composite quasar spectra to determine galaxy fraction



- Parameterise the fraction of the total flux that is coming from the galaxy as:

$$R_{gq} = \frac{F_{galaxy}}{F_{galaxy+quasar}} \text{ with } 0 < R_{gq} < 1$$

Host Galaxies (II):

- Croom et al. (2002) use 2QZ and to find:

$$L_{gal} \propto L_{qso}^{\gamma}$$

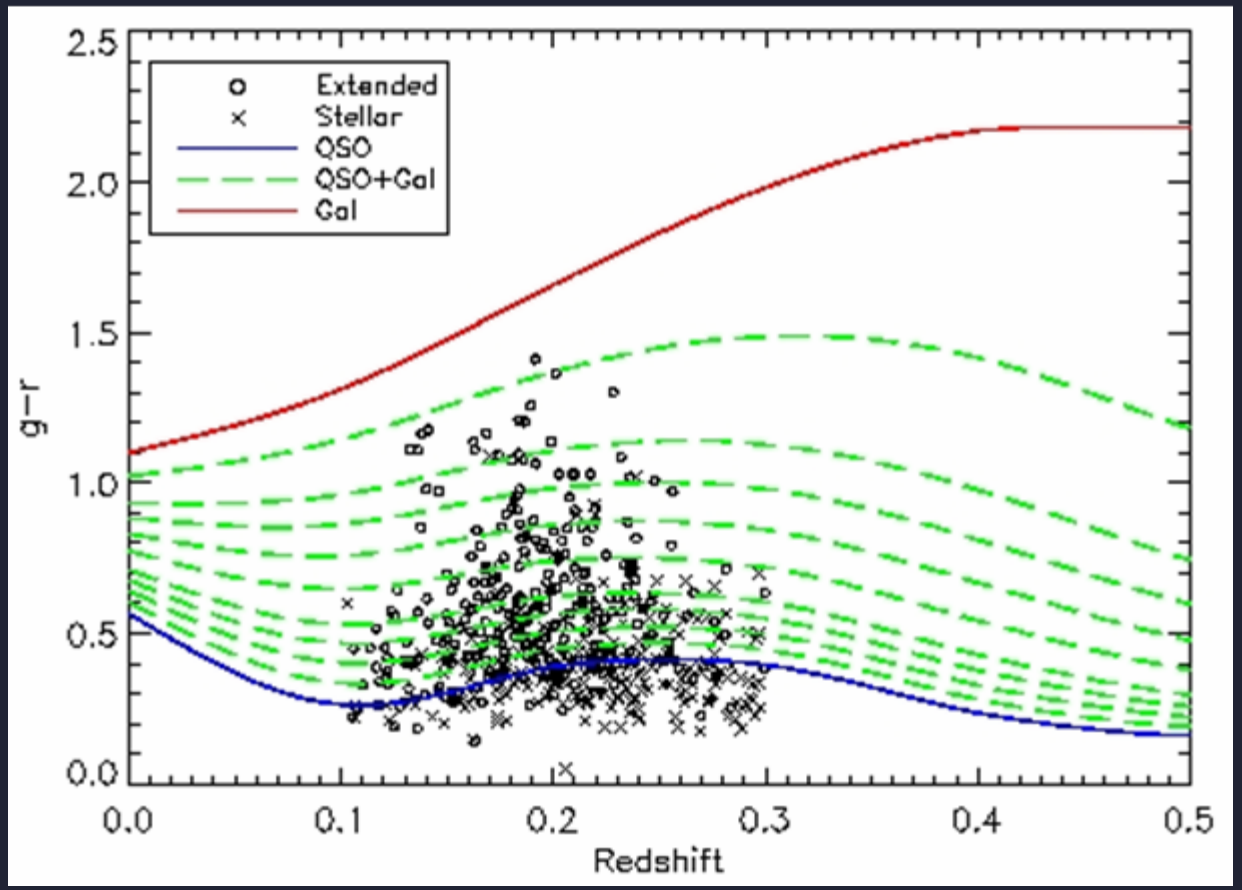
$$M_{gal} = A + \gamma M_{qso}$$

with $\gamma = 0.42$

- The Magorrian relation would suggest that $\gamma=1$
- Galaxy formation simulations (by Lidz et al., among others) are suggesting that $\gamma=0$
- Need normalisation constants, *A*
  - Use SDSS quasar photometry

PSF Magnitudes:

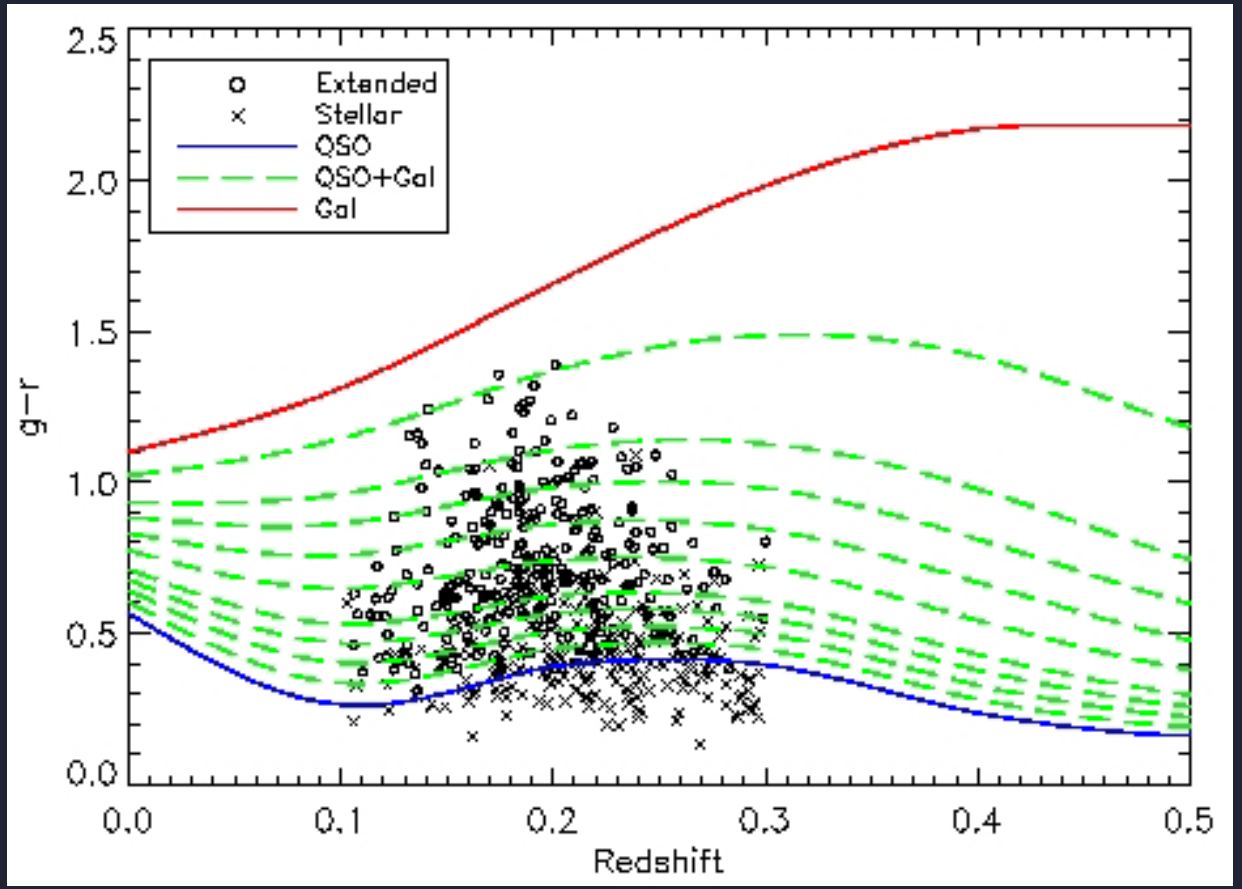
- Recommended for quasars
- Should measure only nuclear component
- If assume increasing host galaxy flux will cause redder colour…



➢ Significant host galaxy flux contributing to the PSF magnitudes of quasars

Petrosian Magnitudes:

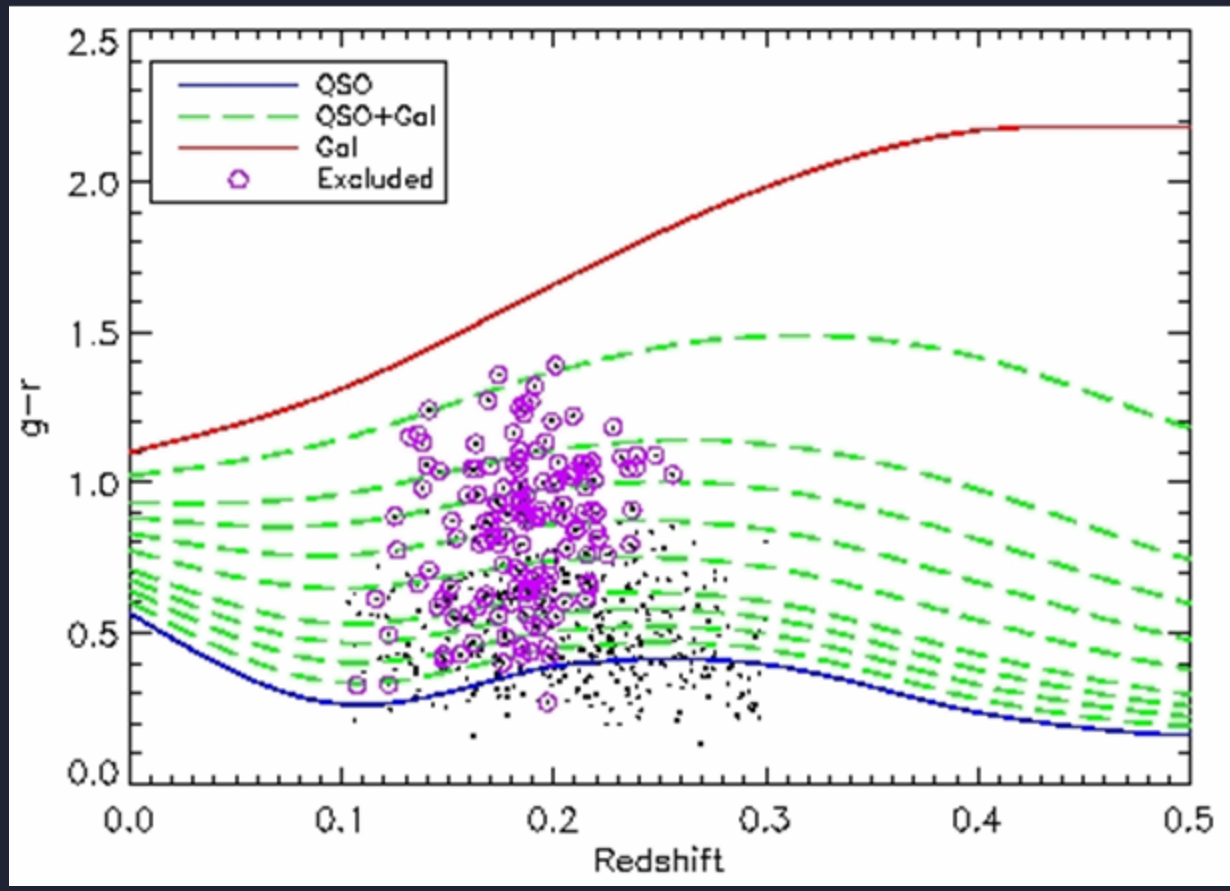
- Measures quasar light and light from the host galaxy
- Position on (g-r), redshift plane gives estimate of R_{gq}



- From R_{gq} can separate M_{gal} and M_{qso}

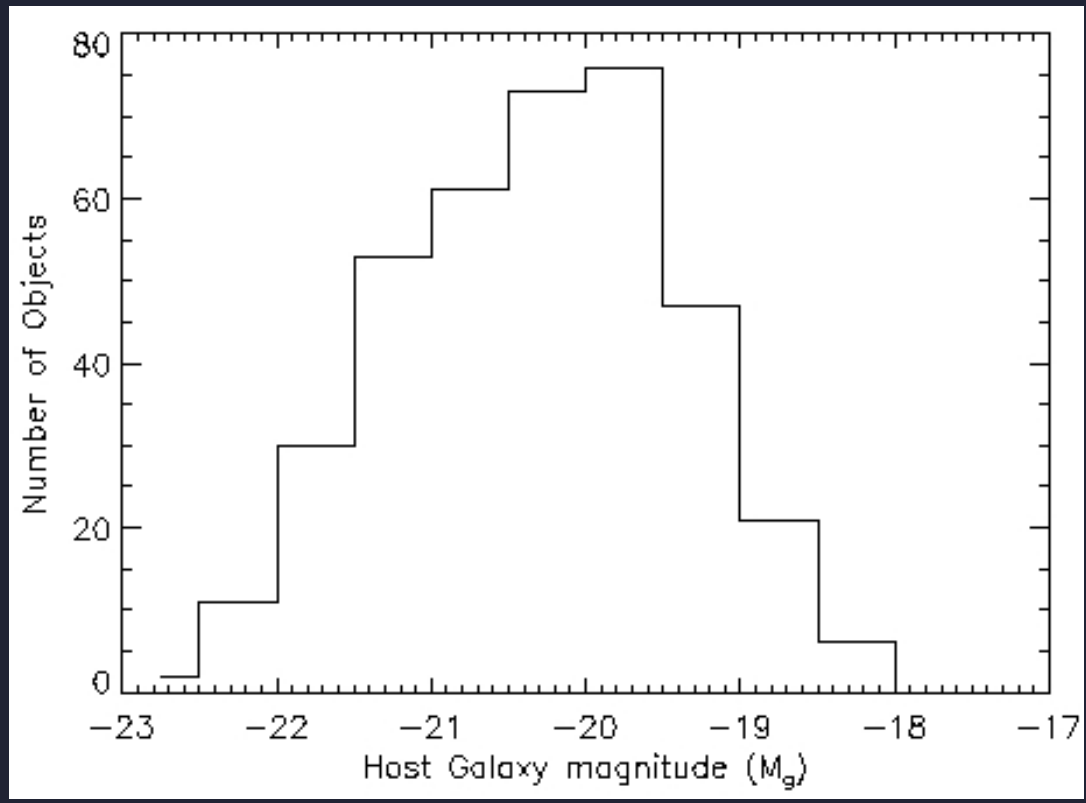
Petrosian Magnitudes:

- ~30% of the sample no longer have quasars that meet the absolute magnitude criterion
- Left with well-defined sample of quasars, complete with the magnitudes of their host galaxies



Quasar and Galaxy Distribution:

- Know the distribution of quasars with a given galaxy fraction
- Distribution of galaxy magnitudes and normalisation constants, *A*, to be used in the simulations



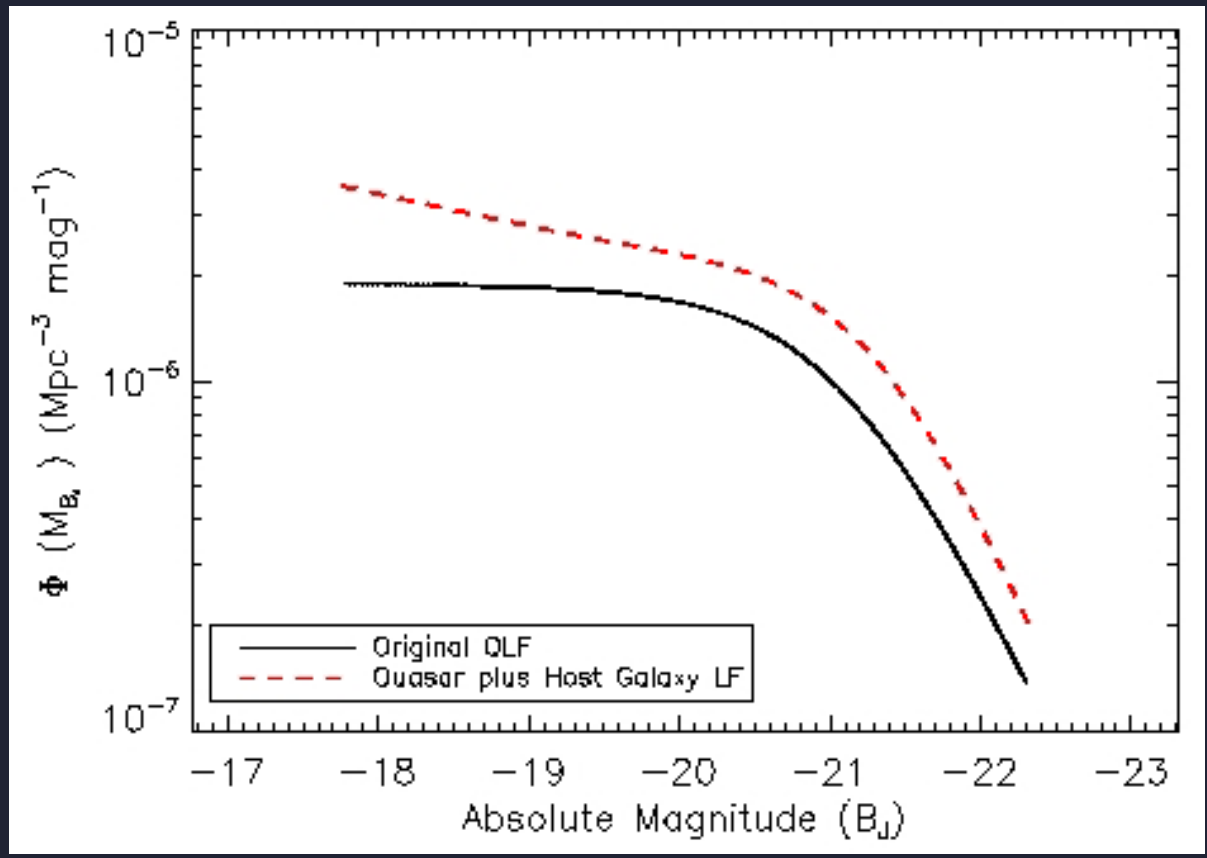
- Have empirically determined distribution of galaxies for known sample of quasars at z~0.2

Combine the ingredients:

- Start with QLF defined in b_J
- Choose γ=0.42 and distribution of *A*'s
- Add host galaxy flux to that of the quasars at each redshift
- Transform the whole thing to the survey passband (i (7500Å), Y (1μm), K(2.2μm), …)
- Impose restrictions ($M_{tot}(b_J)$<-22, R_{gq}<0.8)
- Count the quasars

Results:

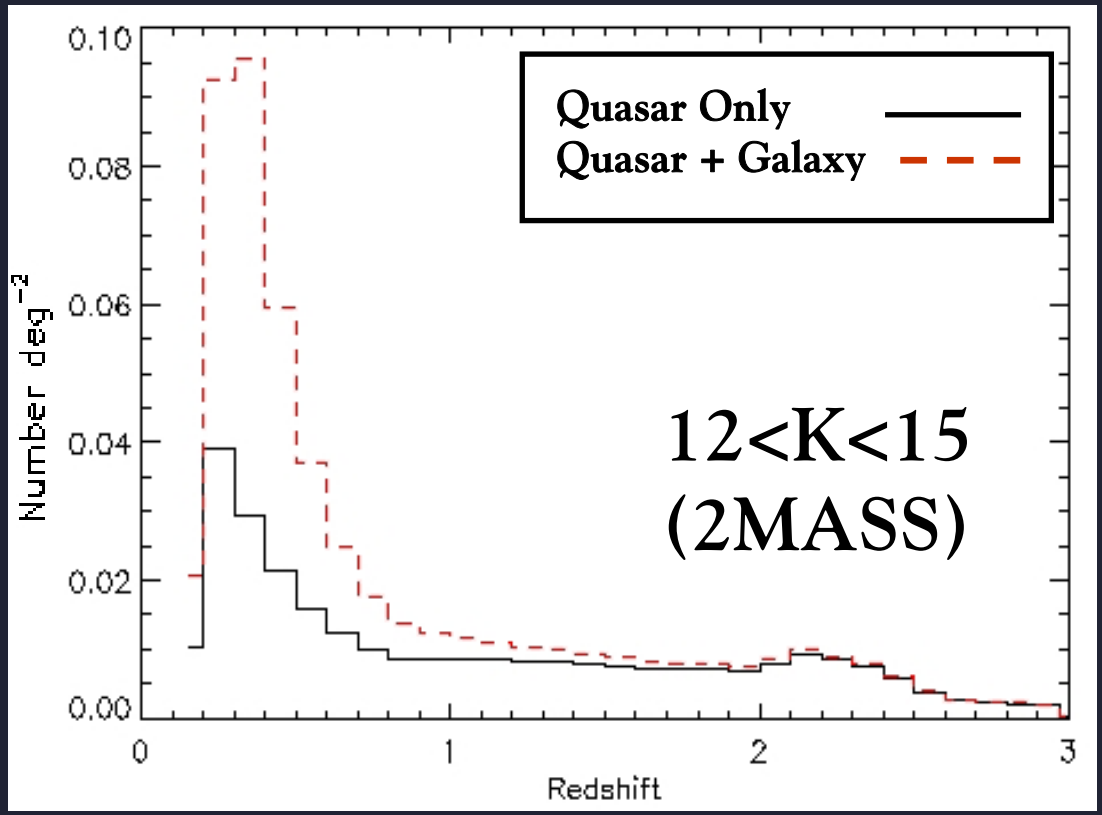
- Adding host galaxy flux to quasars changes shape and normalisation of QLF, particularly at low redshifts and faint quasar magnitudes



Number-Redshift:

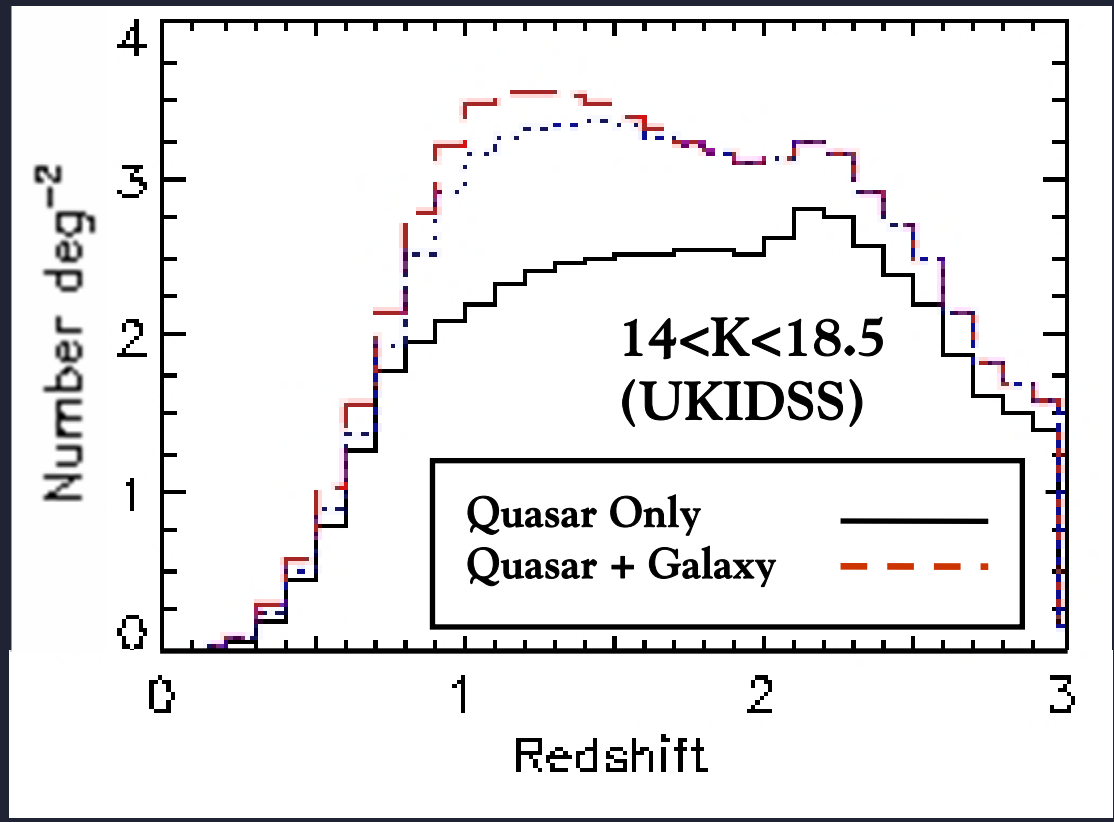
Note: Results are for 1 deg^2

- Number-redshift counts significantly increased in NIR due to addition of host galaxy flux



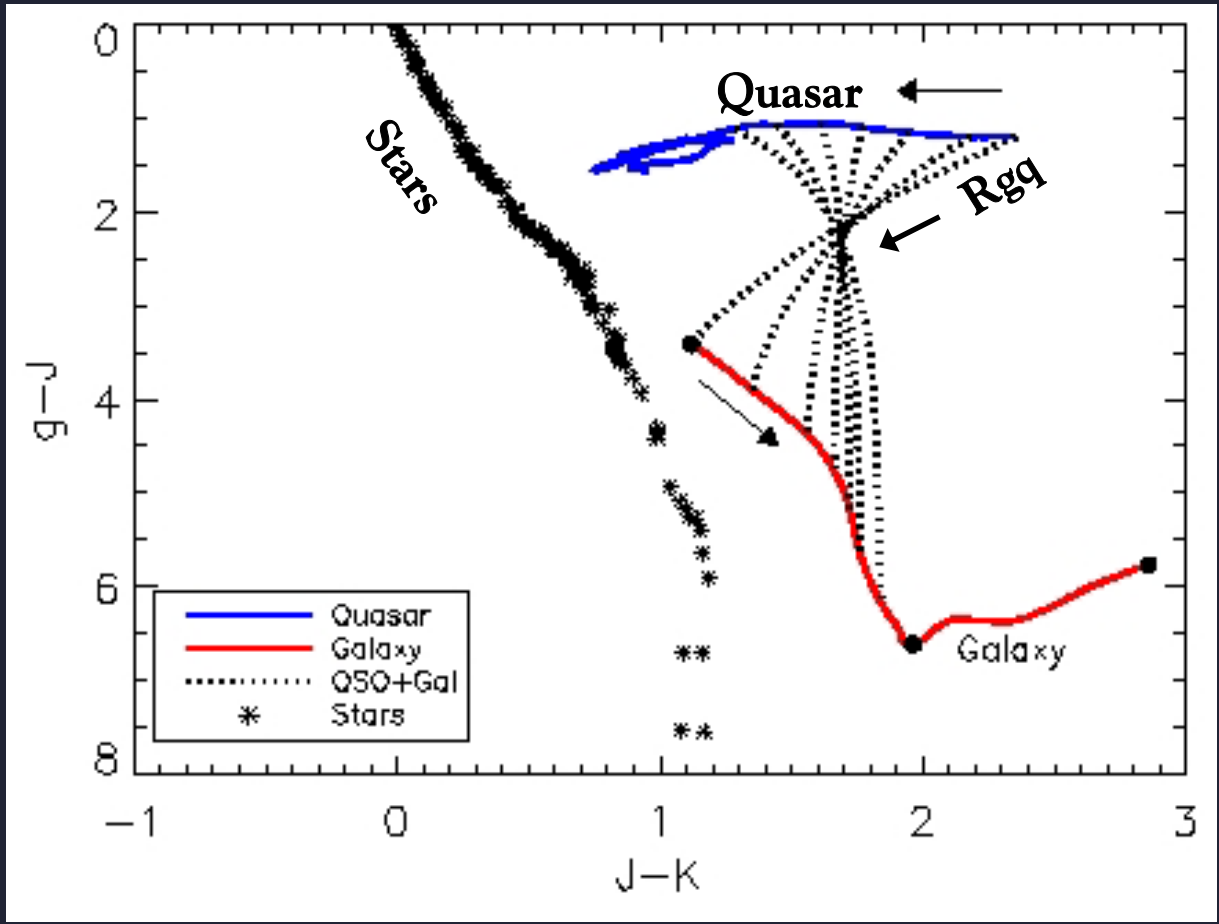
Number-Redshift:

- Number-redshift counts in deep NIR survey affected to high redshift



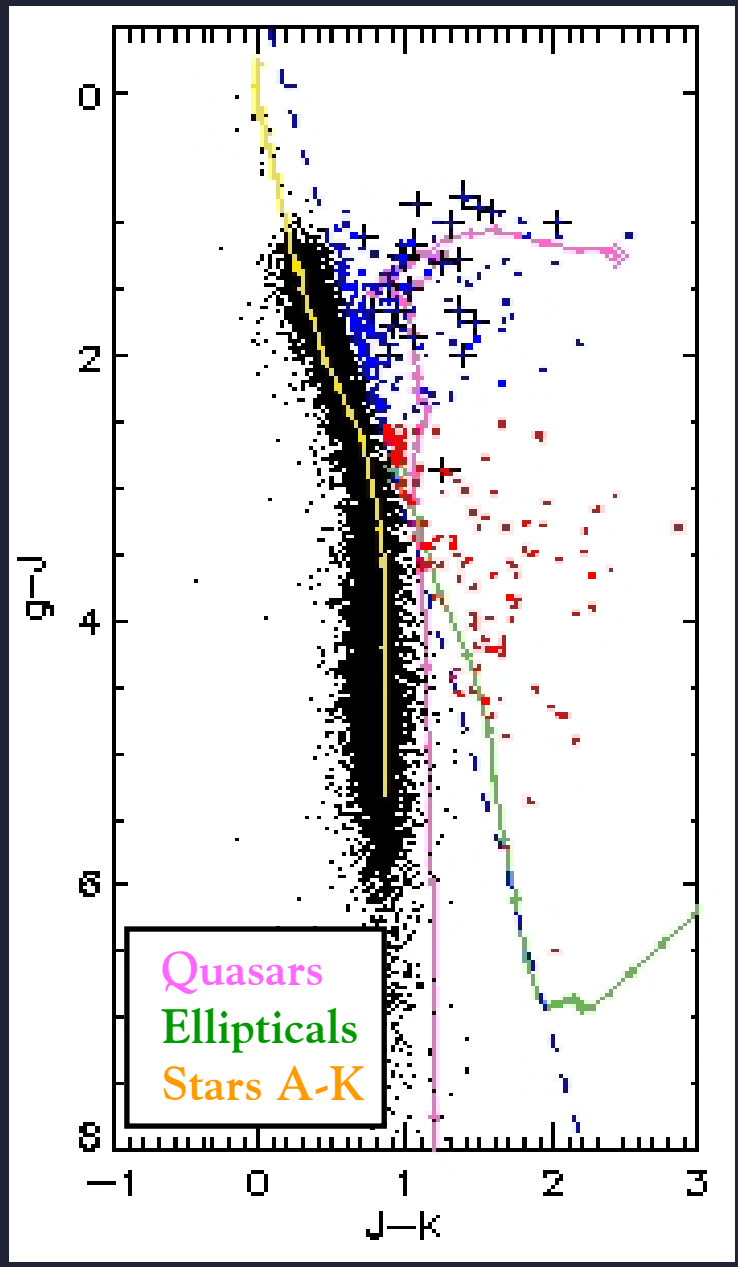
Colour Selection:

- Colour selection for input catalogue
- For K band samples, use K-excess, or KX selection
- Regular and dust reddened quasars stay away from stellar locus
- KX selection still ok for quasar+galaxy colours



Colour Selection:

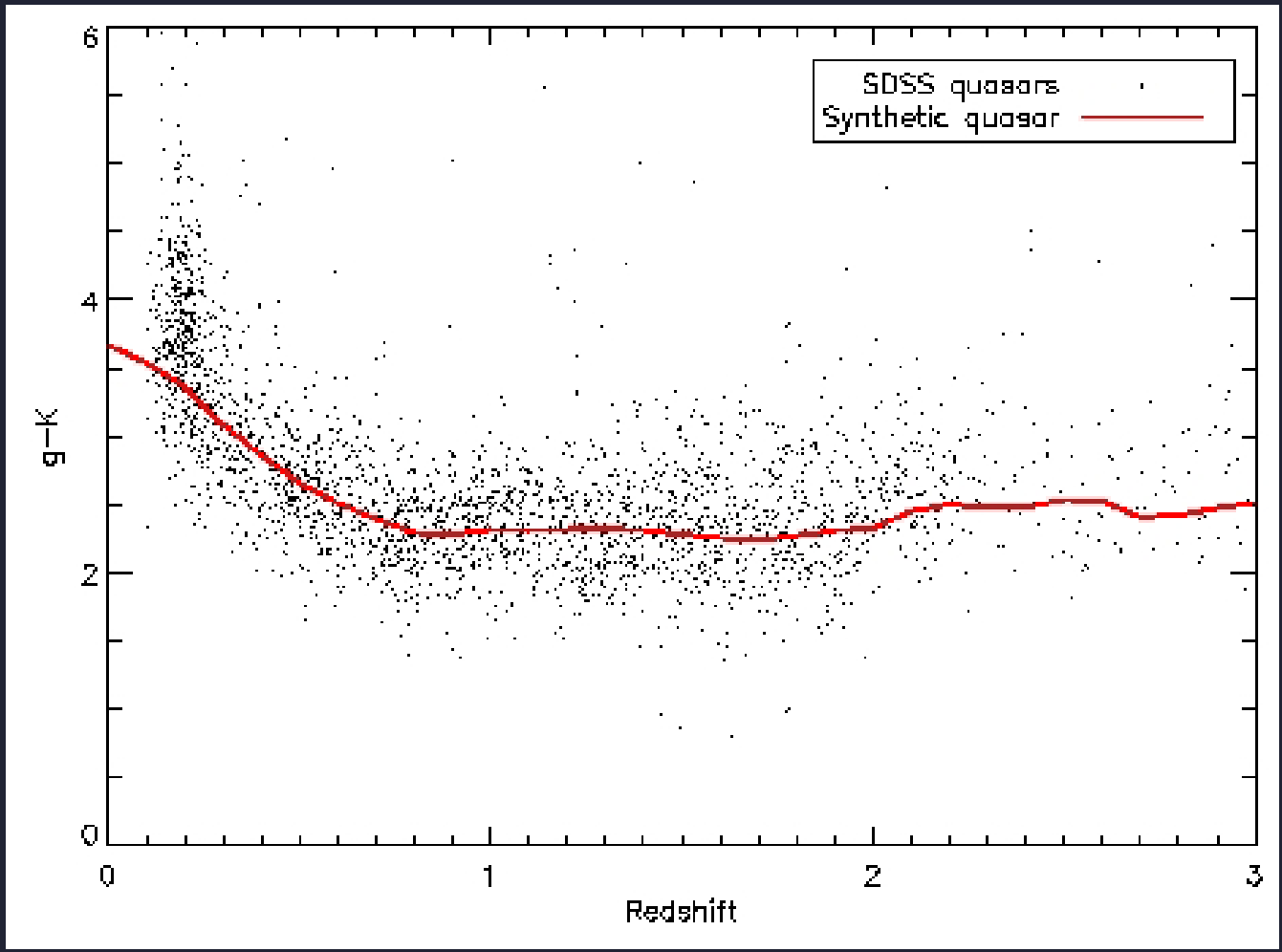
- UKIDSS Science Verification data
- K<17, 10 deg^2
- Optically selected quasars appearing where expected
- AAOmega proposal submitted to determine nature of red objects



Data courtesy of Steve Weatherley

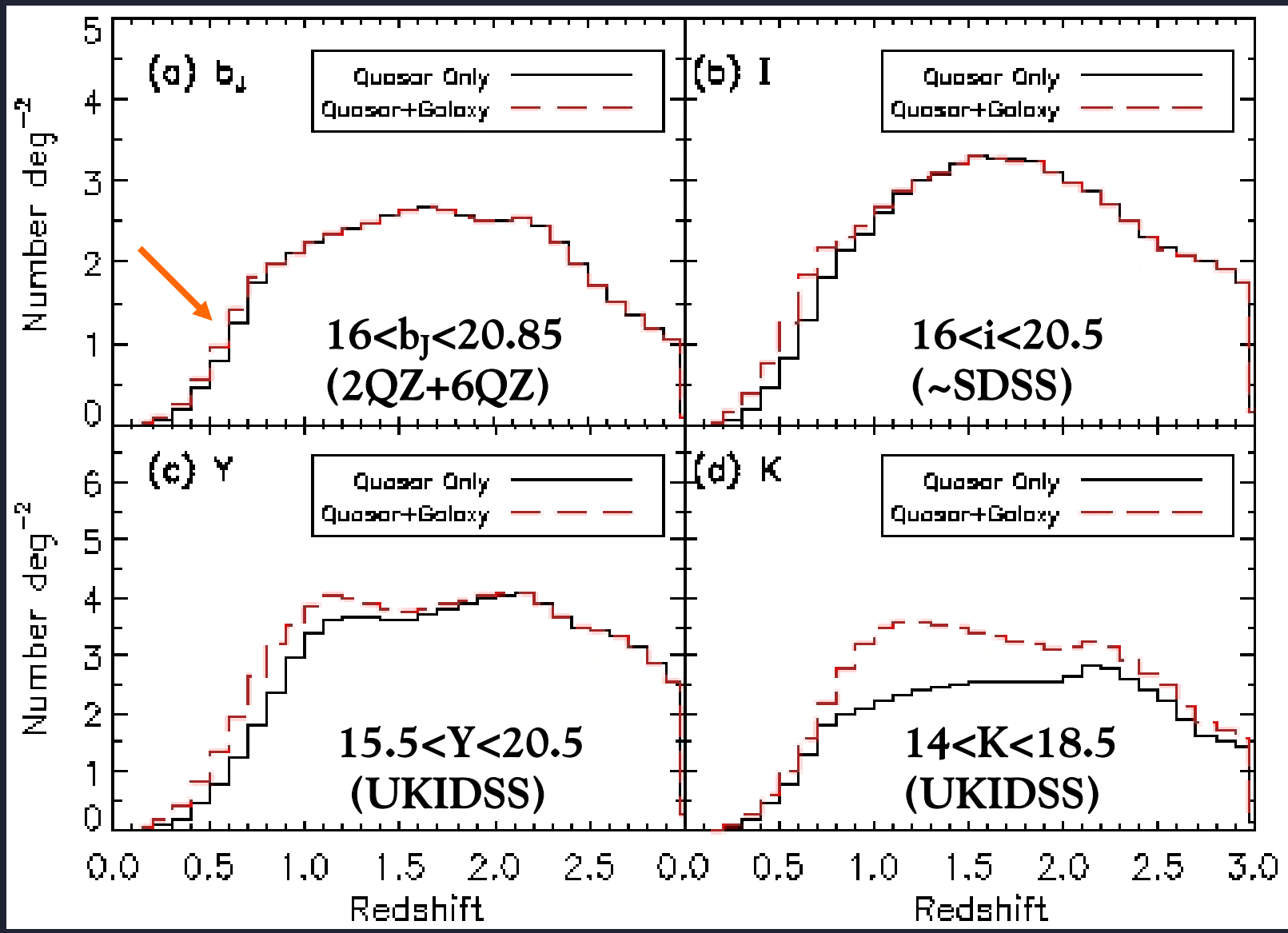
Summary:

- Predict unobscured quasar number-redshift distributions in NIR using information from optical surveys
- Number counts increased by 2x in NIR
- Use predictions as reference for existing and future surveys
- Empirical determination of distribution of quasar host galaxies from SDSS quasar catalogue
- Important to use correct shape of quasar SED
- Galaxy SED not important
- Morphological (R_{gq}) selection can be important

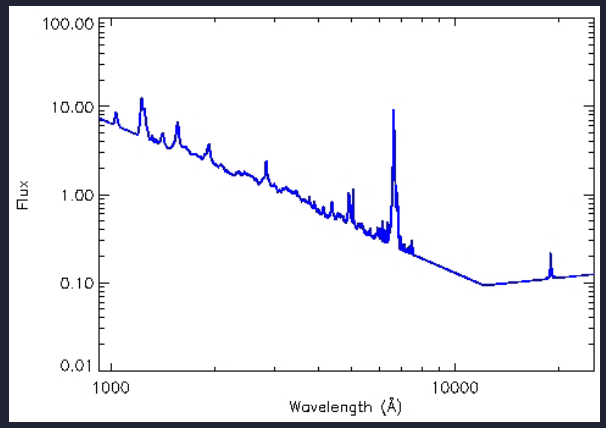


- Match to colours of bright subsample of SDSS quasars

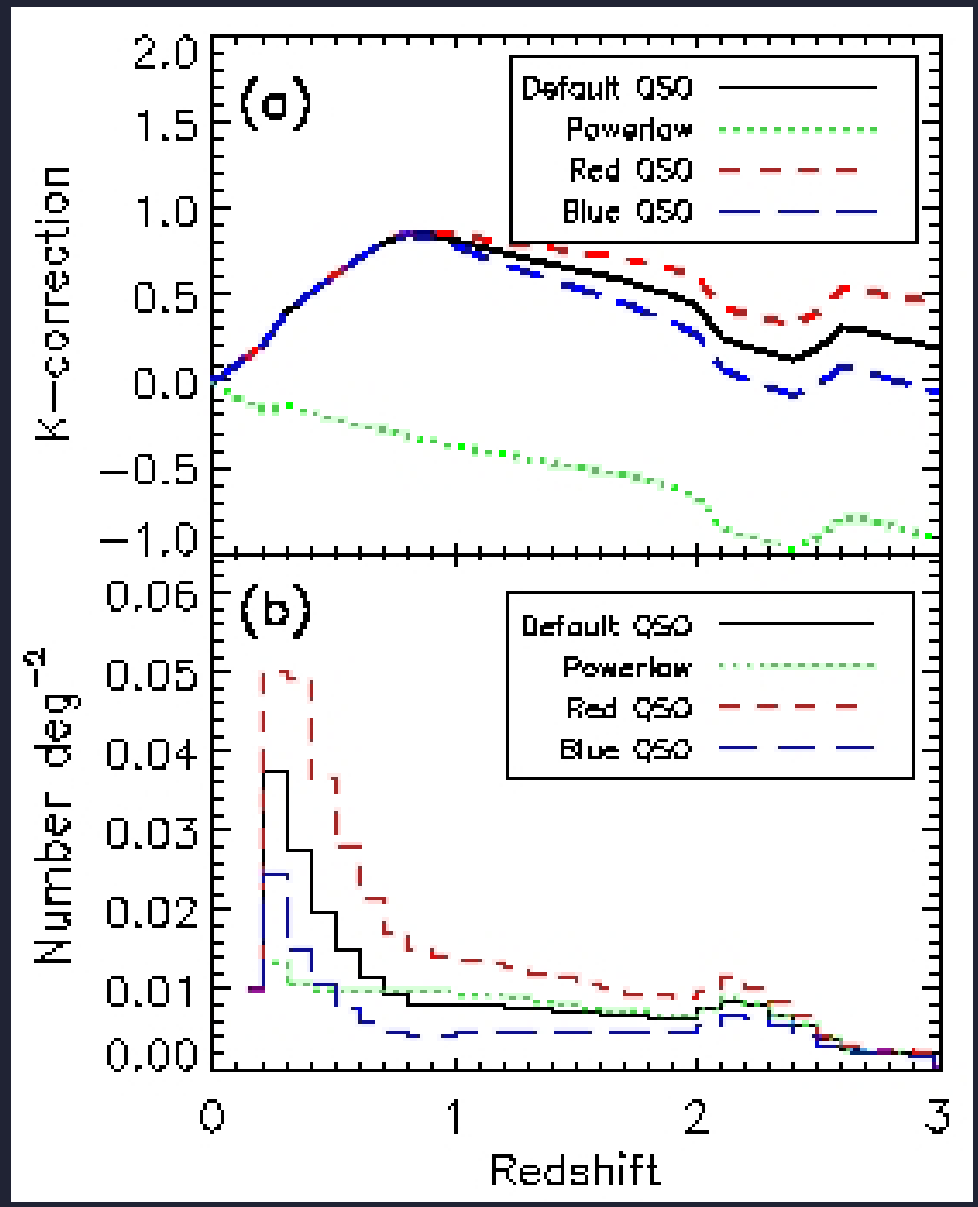
Number-Redshift:



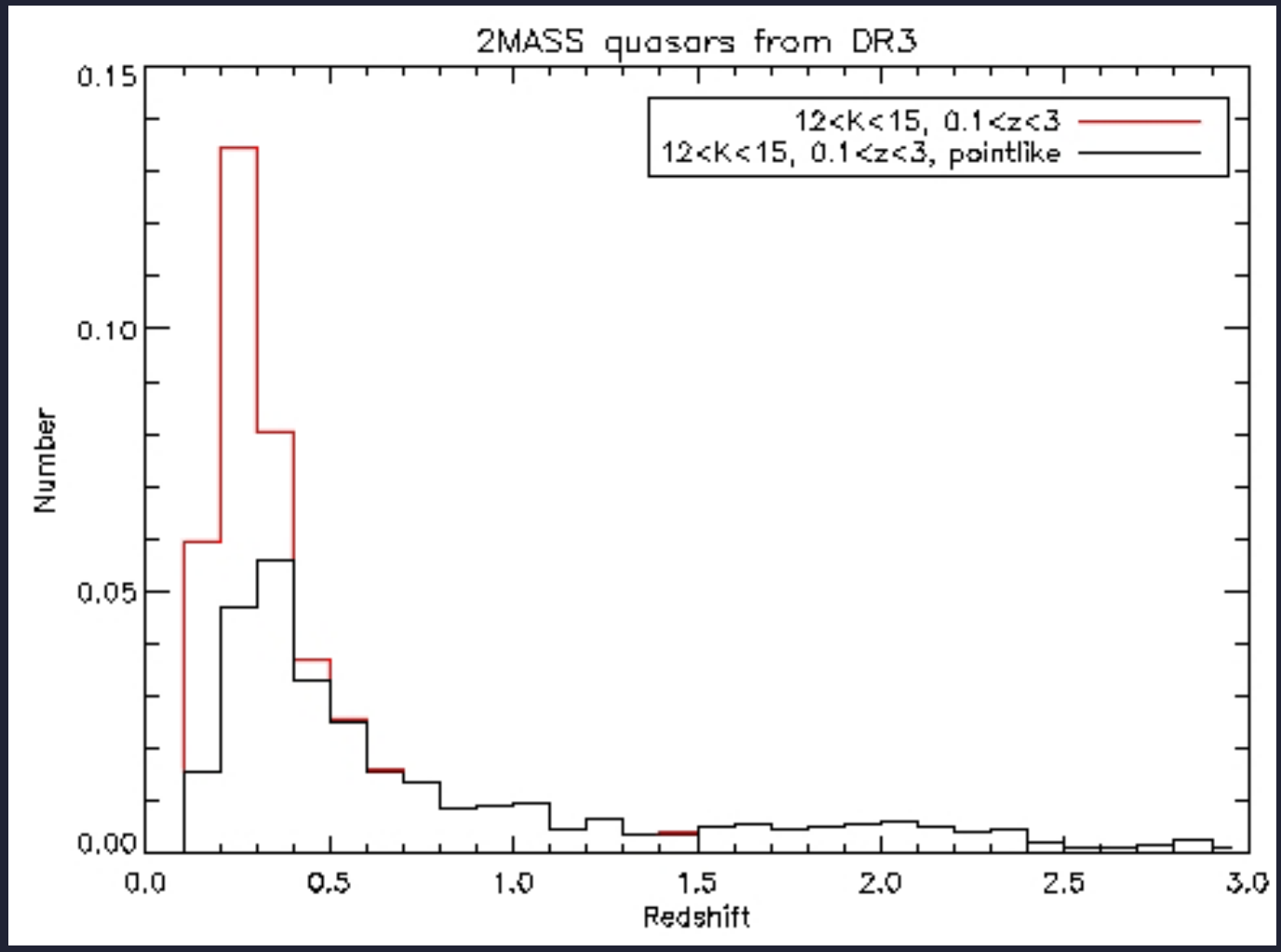
Quasar SED:



- Importance of SED power-law slope longward of 1.2μm
- Low redshift number counts increase by factor of 3

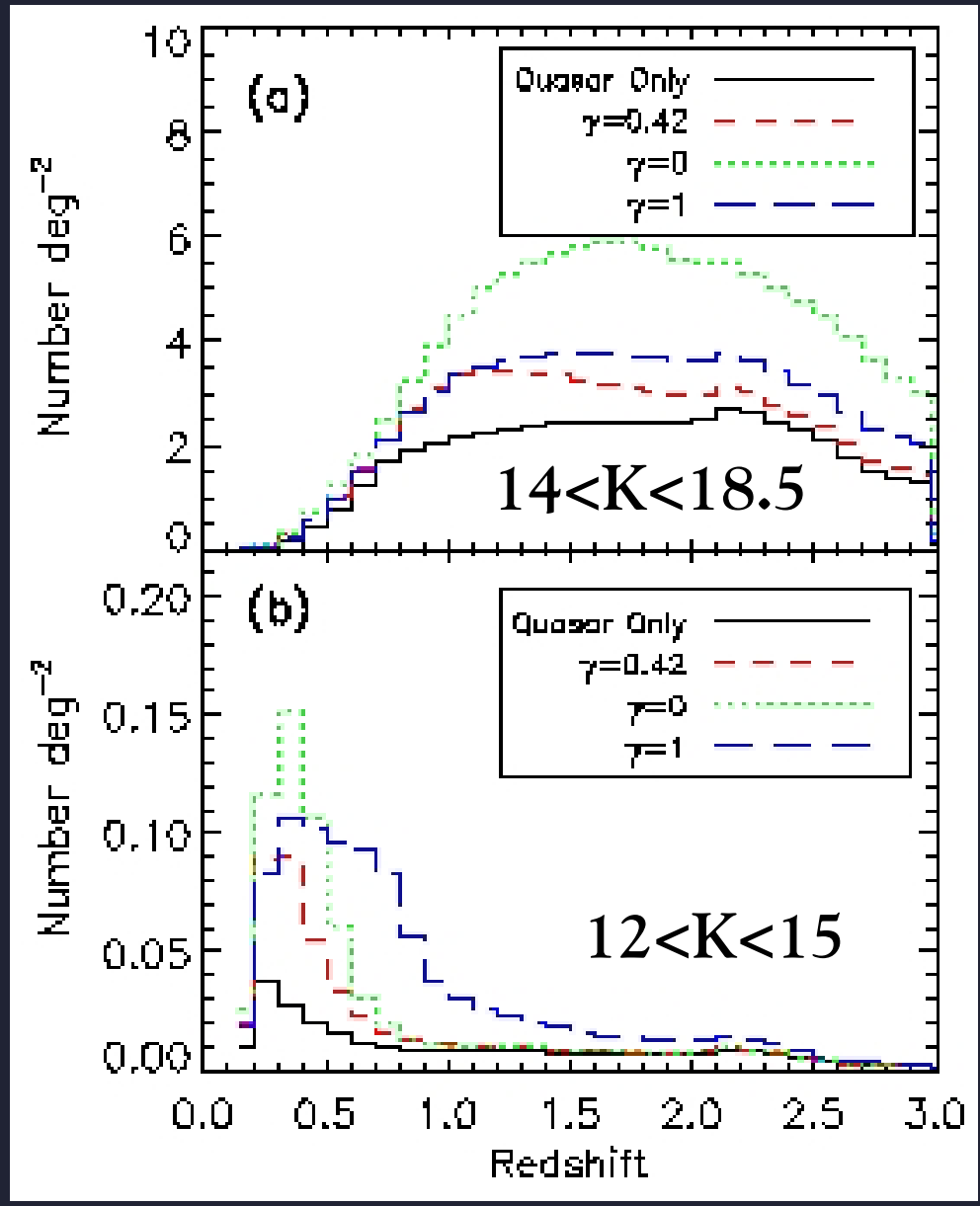


2MASS Quasars from SDSS DR3:



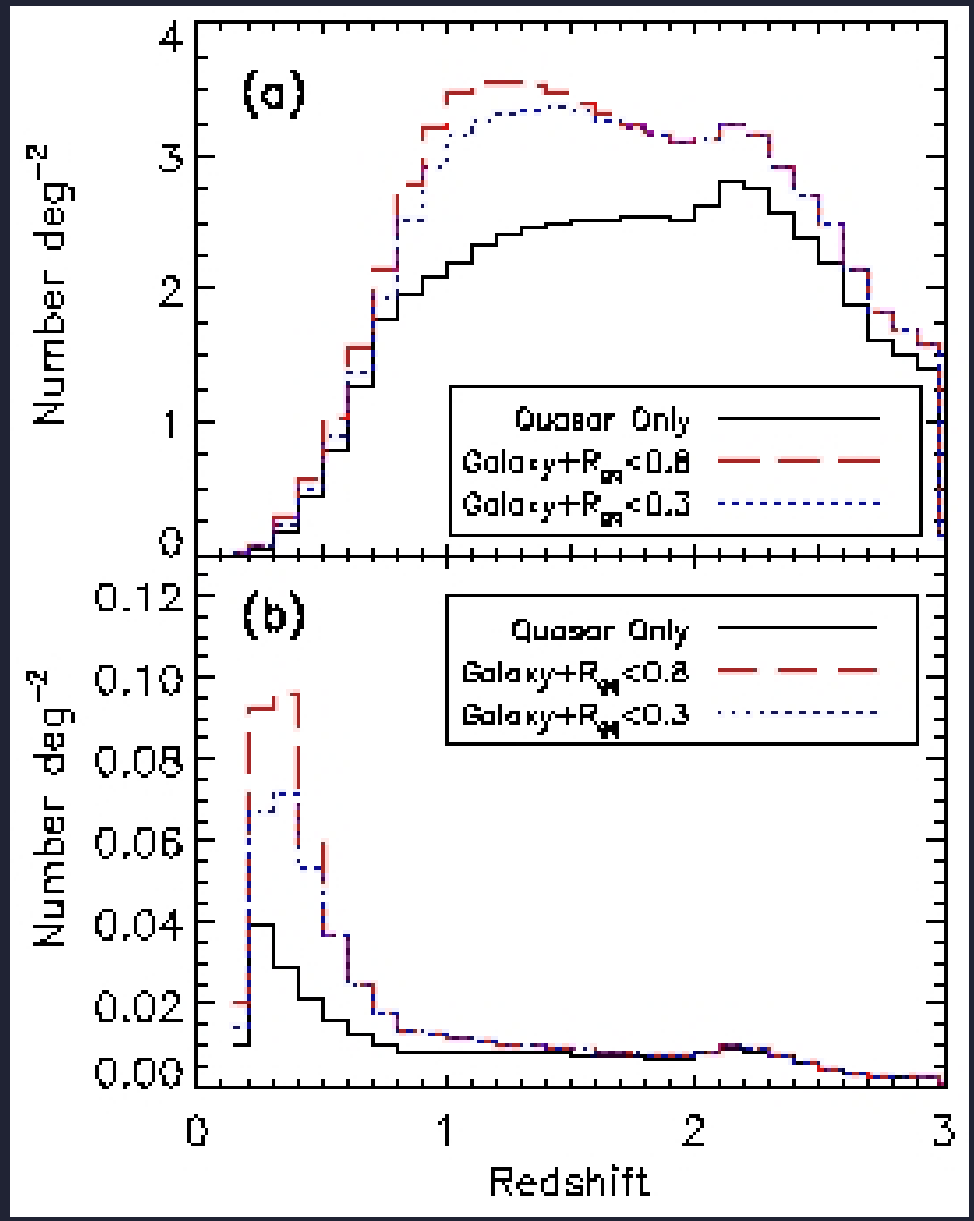
Different γ's:

- For γ = 0, 1, 0.42
- For a deep, NIR survey, high redshift counts significantly affected
- Potential to discriminate between M_{gal}, M_{qso} relations



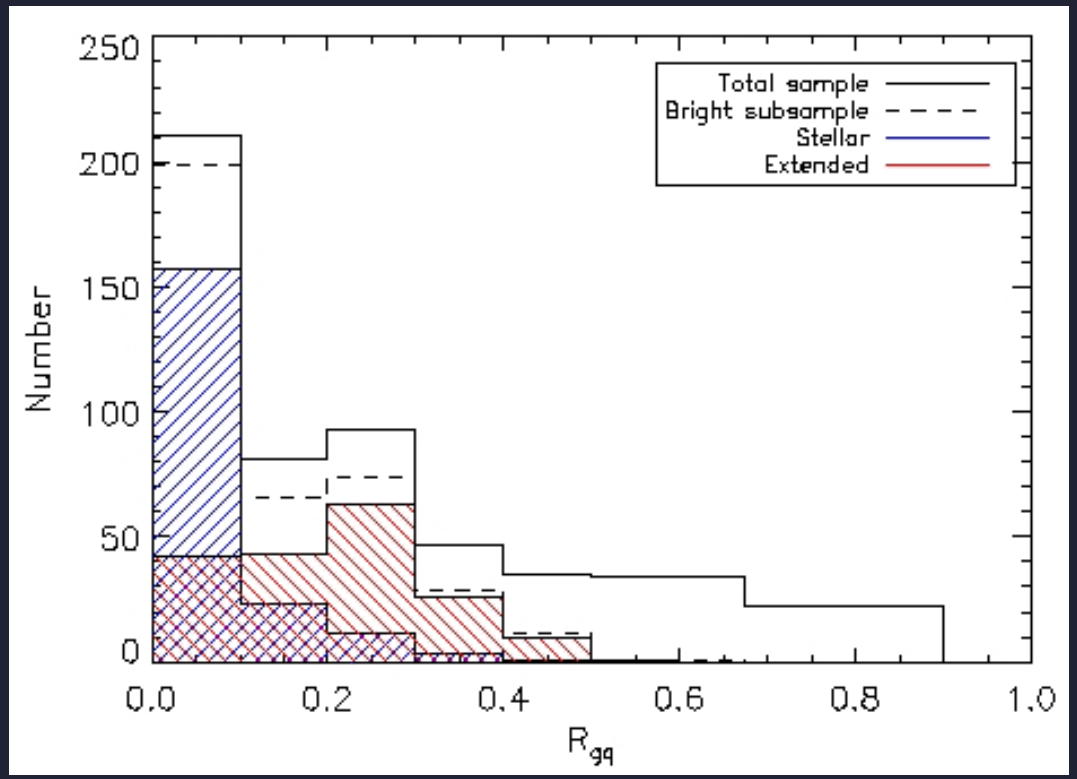
Different Morphological Selection:

- Makes very little difference at short wavelengths
- Makes significant difference at low redshifts



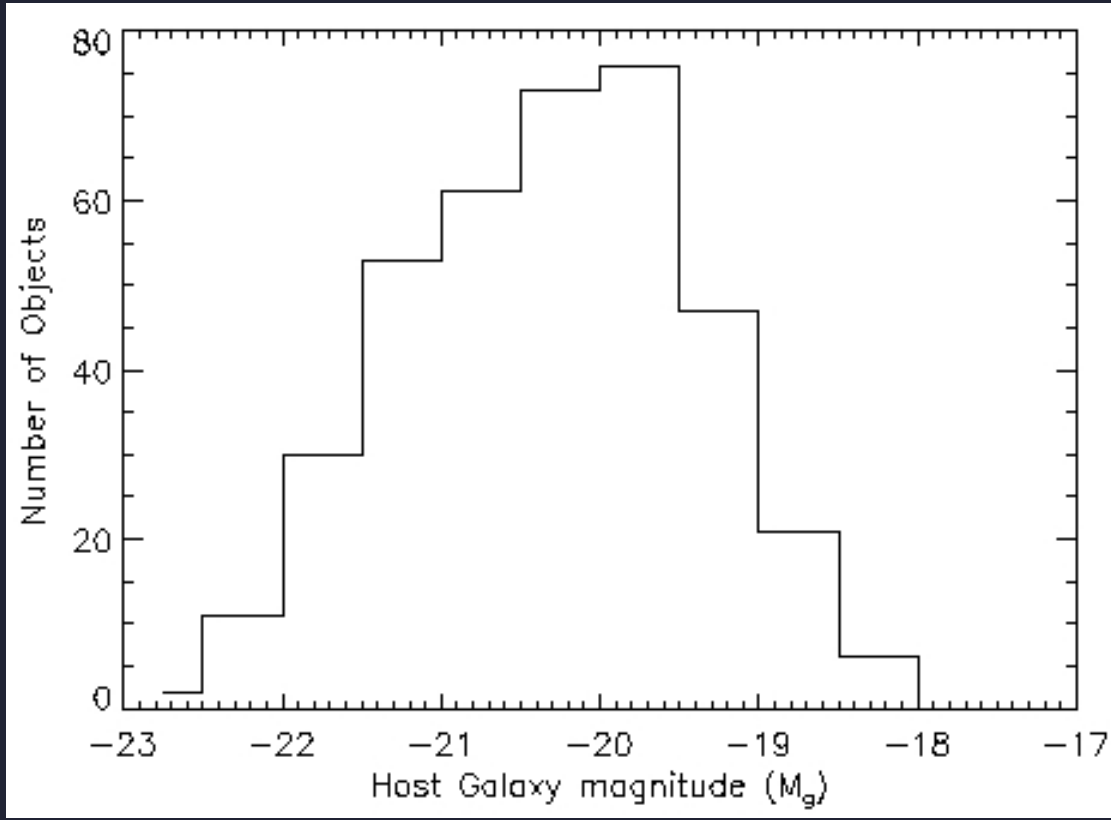
Quasar Distribution:

- Histogram gives the distribution of quasars with a given galaxy fraction
- Distribution of galaxy magnitudes and normalisation constants, *A*, to be used in the simulations



Galaxy Distribution:

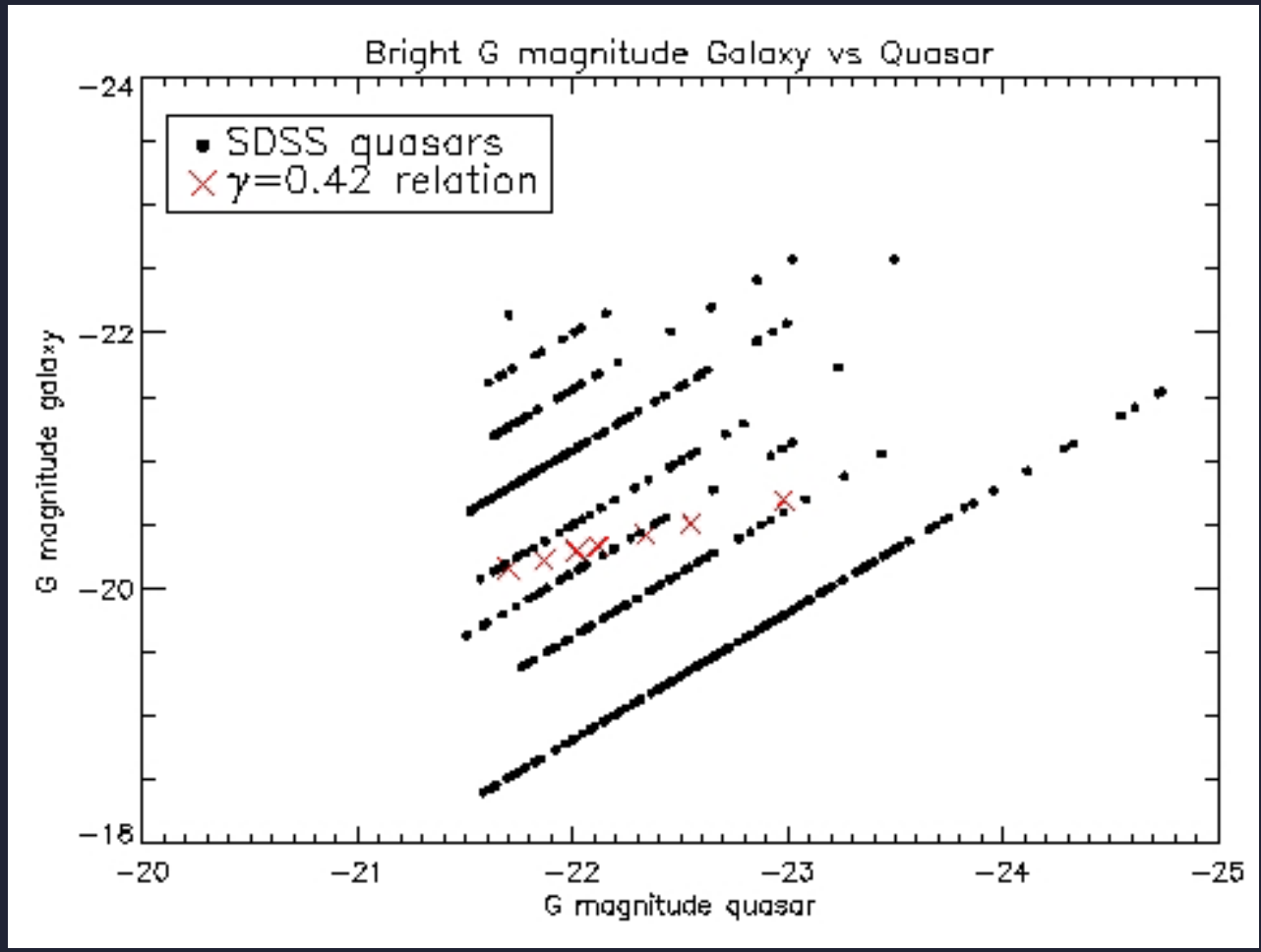
- Have empirically determined distribution of galaxies for known sample of quasars
- Gives quasar-galaxy luminosity relationship



- Quasar magnitudes corresponding to these are $-24.75 < M_g < -21.5$

SDSS Quasar and Galaxy Magnitudes:

- Quasar magnitudes don't span large enough range to determine M_{gal}, M_{qso} relation
- Croom relation fits data acceptably



Totals (number per deg^2):

Band	Quasar Only	Quasar+Galaxy
$16<b_J<20.85$	52.4	52.9
$16<i<20.5$	63.7	66.1
$15.5<Y<20.5$	81.7	88.1
$12<K_{2MASS}<15$	0.3	0.5
$14<K<18.5$	55.0	70.5