

# Quasar Environments from the SDSS

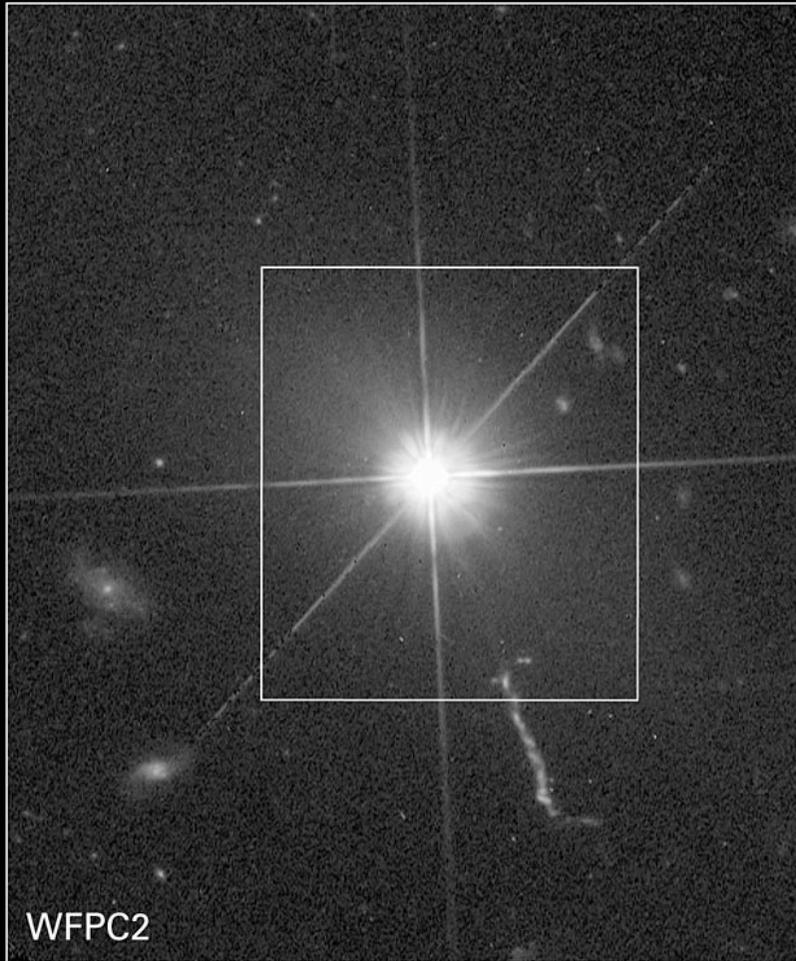
<http://trotsky.arc.nasa.gov/~mway/qso-sdss.pdf>

# Quasars – What are they?

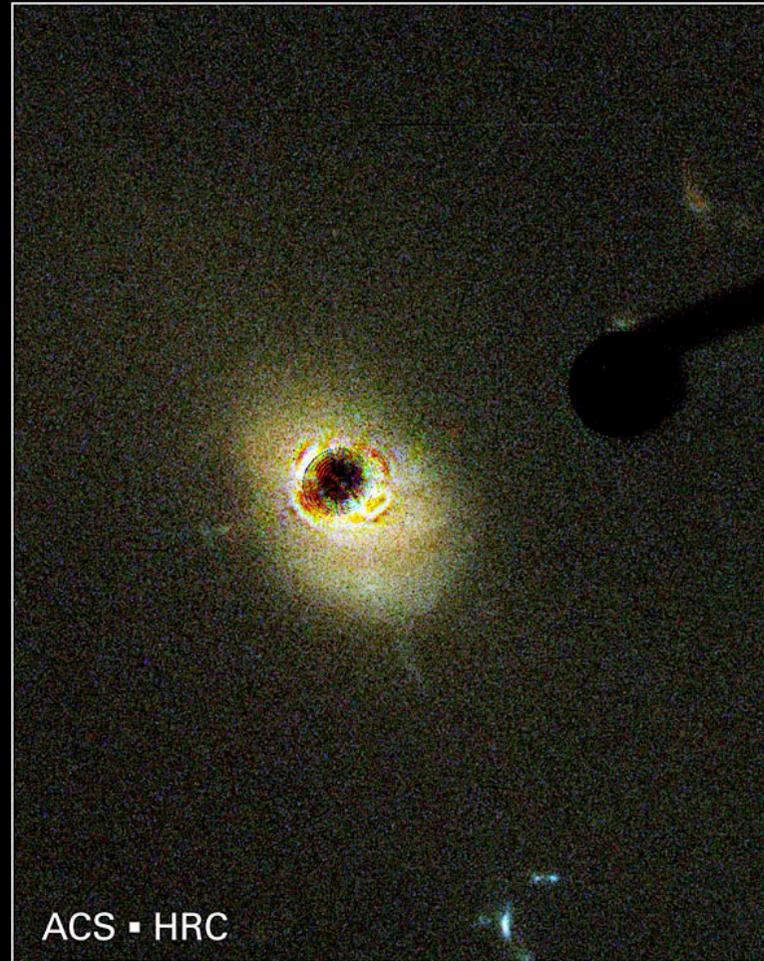
- Quasar: A Quasi-Stellar Object
  - Quasi-Stellar Radio Source
- 3C273 first understood in 1962 by Maarten Schmidt using the 200-inch on Mount Palomar
- Spectral lines of hydrogen were measured redshifted at the rate of 15.8 percent of  $c$ : receding at a rate of 47,000 km/s
- Some of the most distant objects measured

# Quasars – What are they?

- Appear point-like (star-like)
- A host galaxy with a supermassive black hole and accretion disk at the center
- Most continuously luminous, powerful, and energetic objects in the known universe
- SDSS has found over 200,000 (the largest sample today)
- Very luminous in Radio and X-rays too
- Tend to avoid dense regions of universe



WFPC2



ACS • HRC

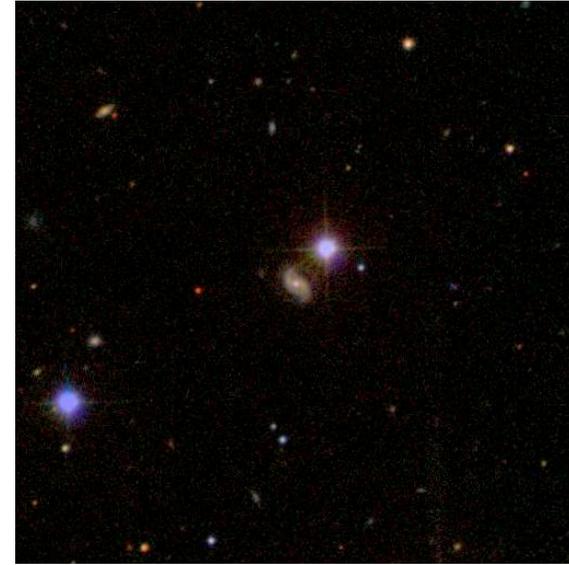
**Quasar 3C 273**

**Hubble Space Telescope • ACS HRC Coronagraph**

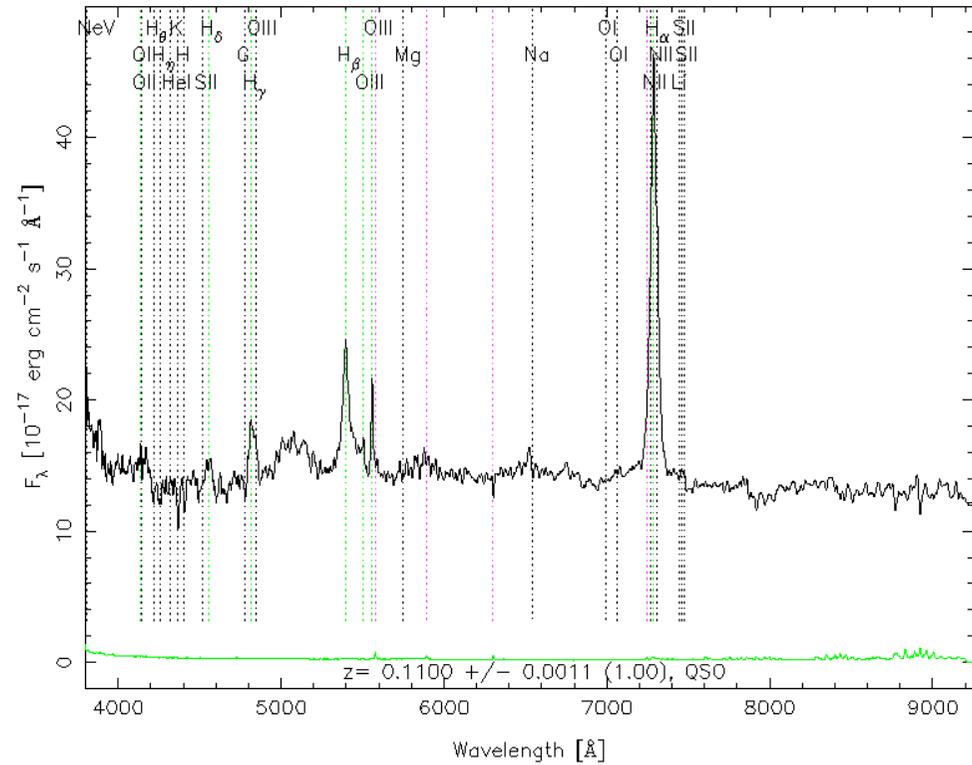
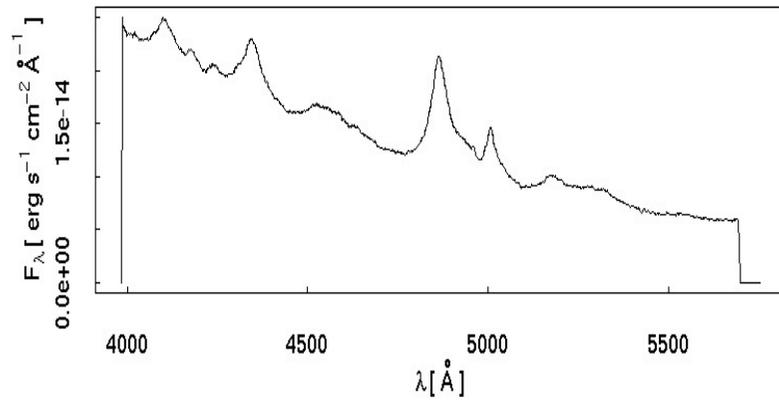
NASA, A. Martel (JHU), the ACS Science Team, J. Bahcall (IAS) and ESA • STScI-PRC03-03

Normal Image (left) – Chronograph (right)

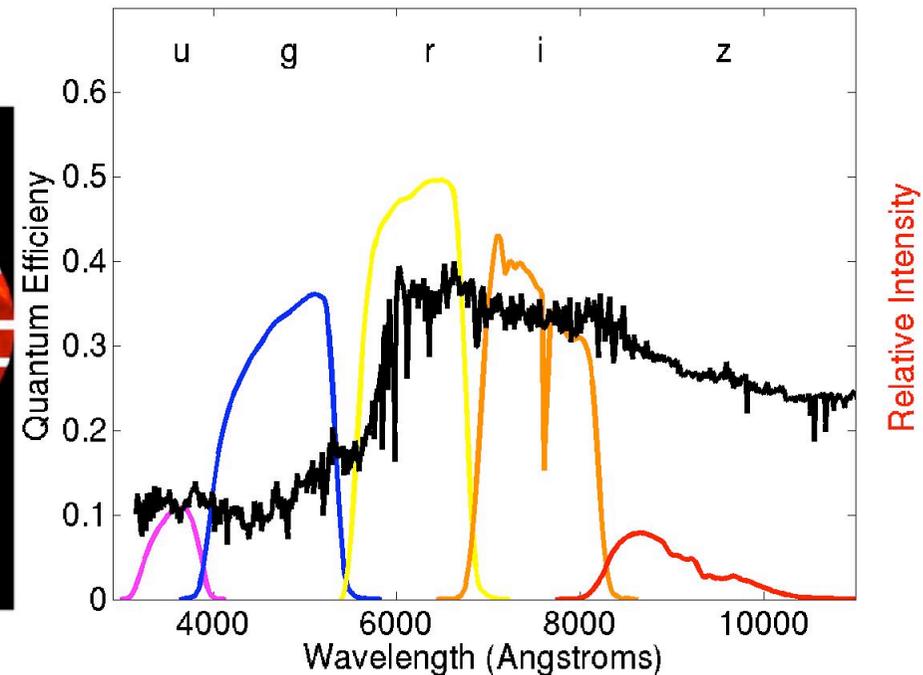
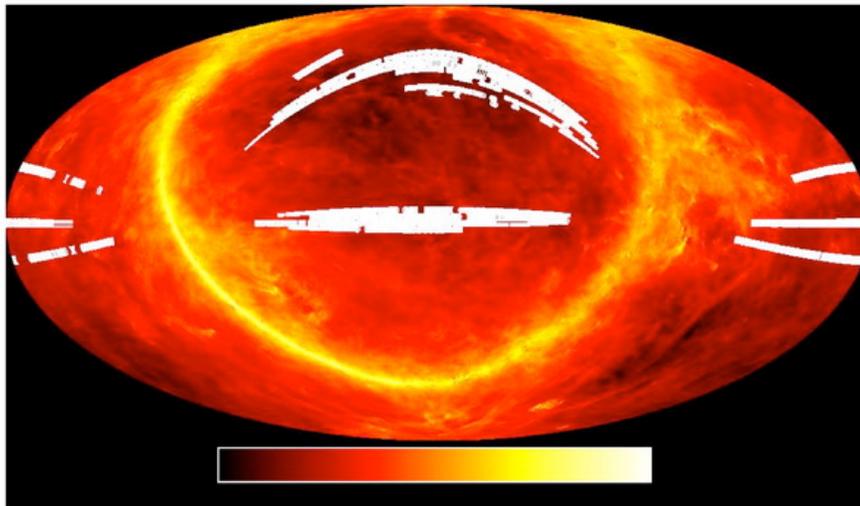
↓ 3C273 (SDSS) : SDSS Obj1 →

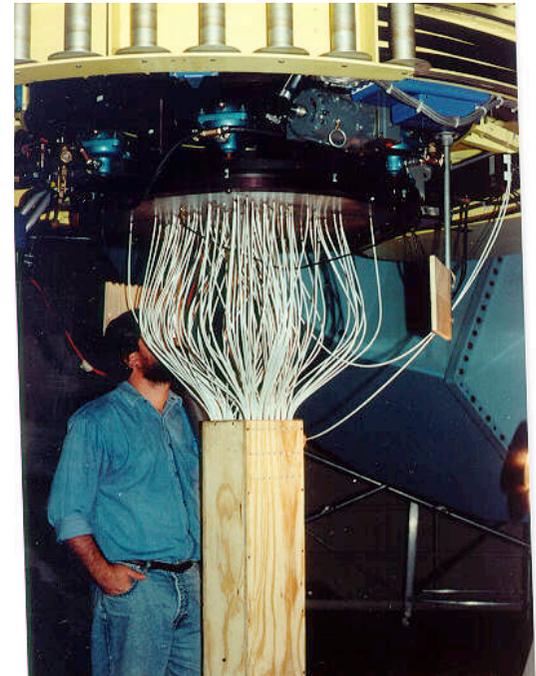
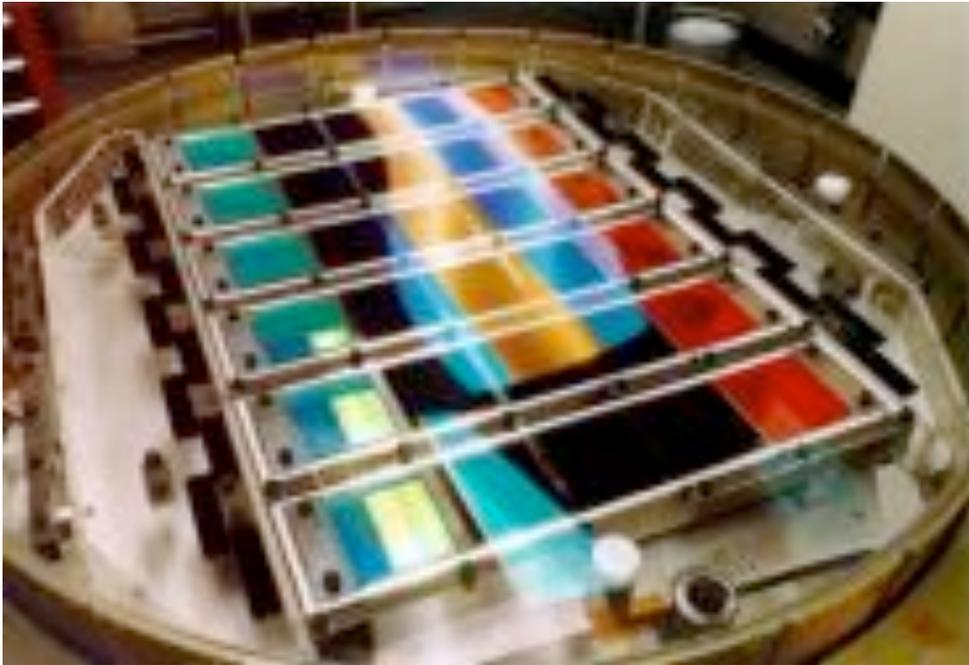
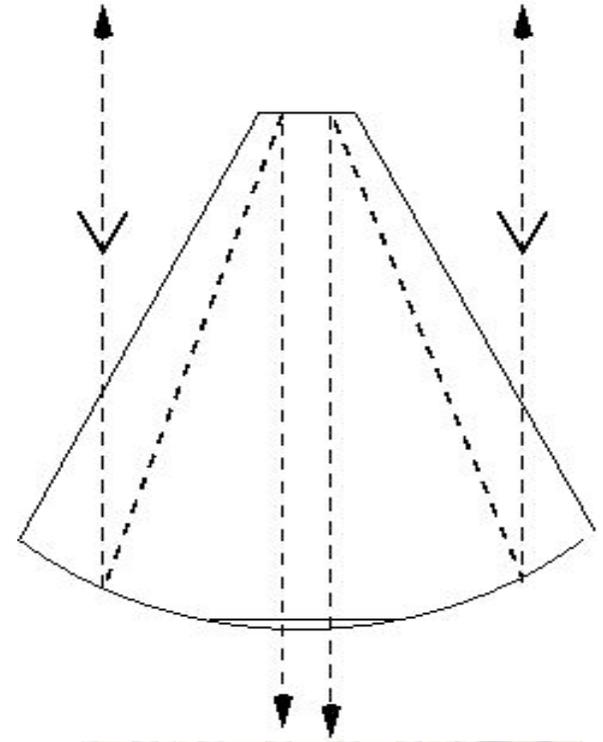


RA=198.11736, DEC= 1.70092, MJD=52295, Plate= 525, Fiber=163



- The SDSS (Sloan Digital Sky Survey)
  - Mostly privately funded 2.5 meter telescope
  - Aim: to survey the south galactic cap in 5 optical bands and take spectra for 1/400 objects
  - Today: 357 million in u,g,r,i,z, 1 million have measured spectra



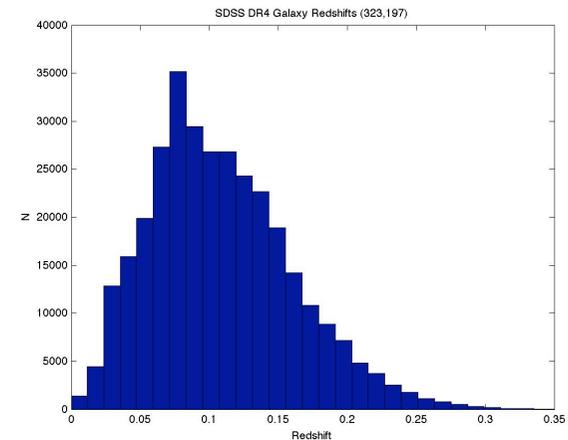


# Project Goals

- Determine properties of galaxies near Quasars from the SDSS
- Do the Quasars affect their neighbors?
- Do the neighbors affect the Quasars?
- Estimate the in-fall rate of galaxies on-to Quasars?
- Estimate the mass/year that must in-fall to power the Quasar?

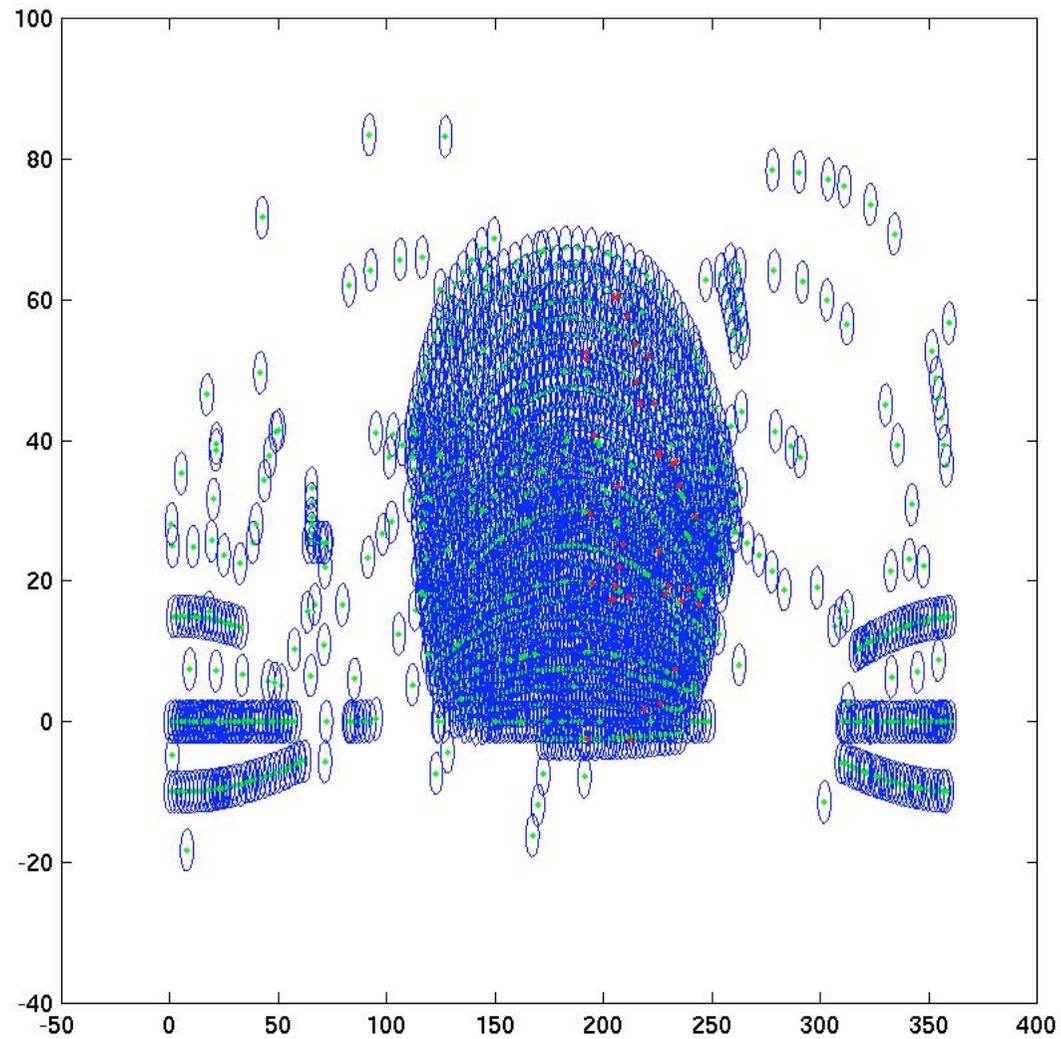
# Selecting galaxies around Quasars: Limitations

- Spectra cannot be obtained for galaxies within 55'' of each other (This affects 6% of the SDSS sample – Strauss 2002, ApJ 124, 1810)
  - $z \sim 0.03 = 0.033 \text{ Mpc (33 Kpc)}$
  - $z \sim 0.1 = 0.1 \text{ Mpc (101 Kpc)}$
  - $z \sim 0.2 = 0.182 \text{ Mpc (182 Kpc)}$

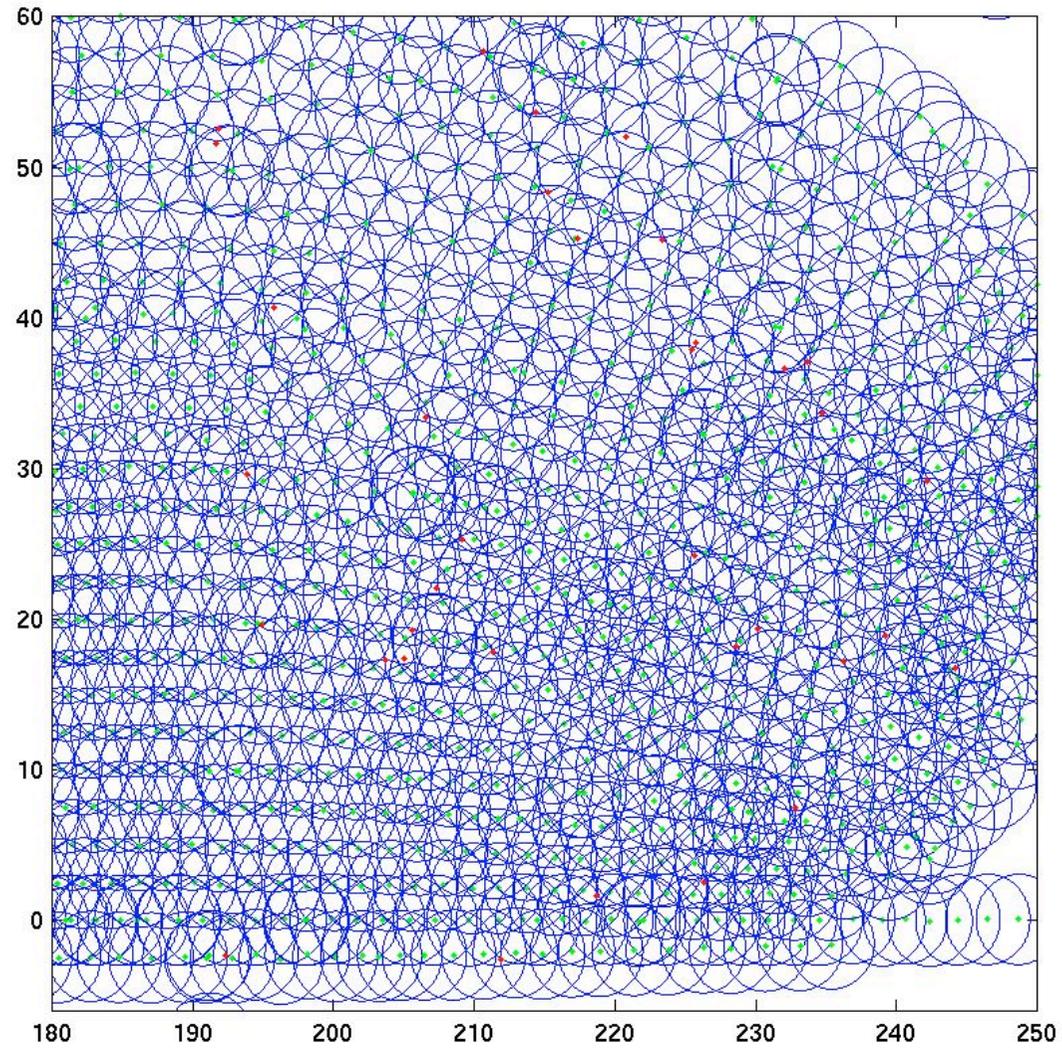


- We want to look well within 350 Kpc, so how can we use the SDSS?

# SDSS Plate Overlap



# SDSS Plate Overlap

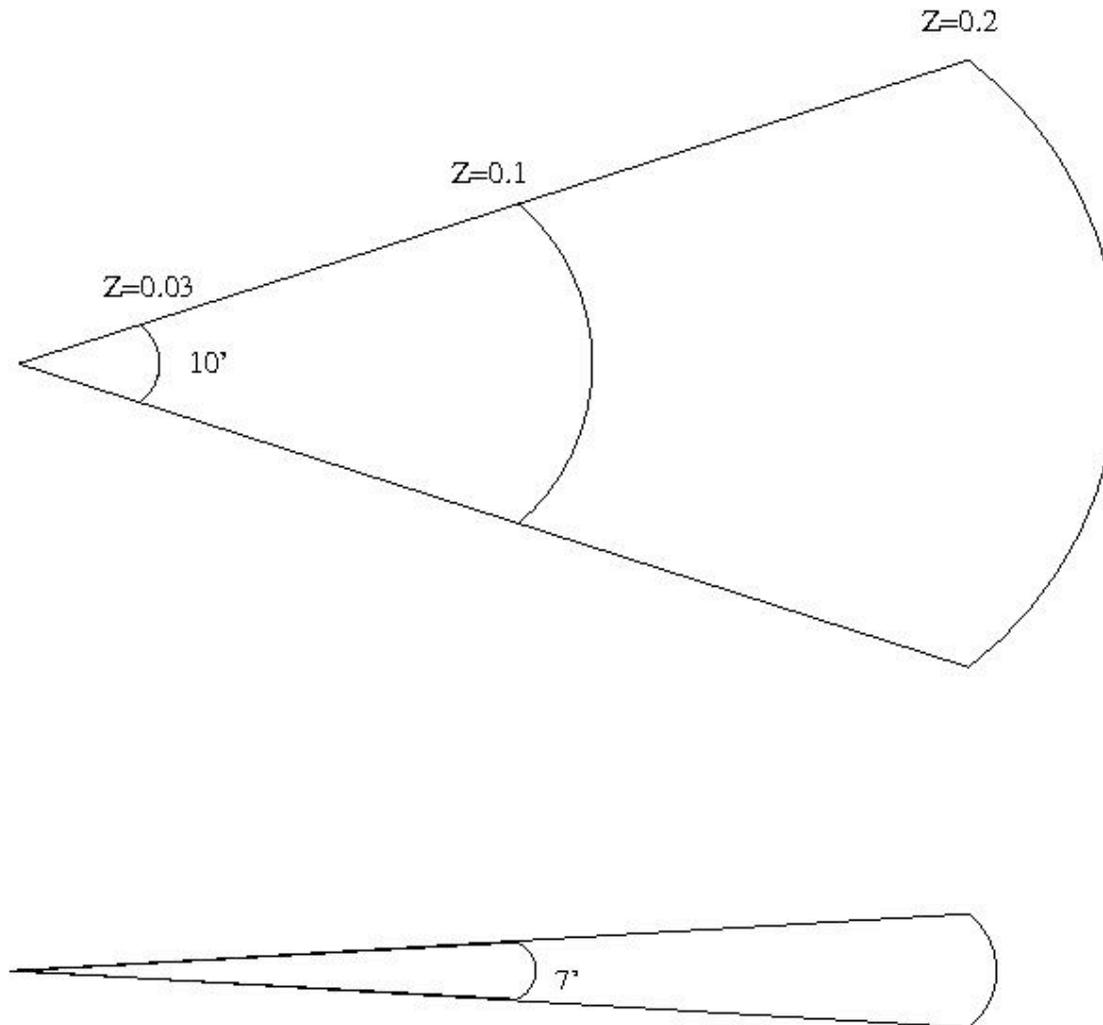


# Selecting Quasar-Galaxy systems

- Restrictions:
  - $0.03 < z < 0.2$
  - Angular separation quasar-galaxy
    - $0.1 < z < 0.2$  ang sep  $< 7'$  ( $\sim < 400$  Kpc)
    - $0.03 < z < 0.1$  ang sep  $< 10'$  ( $\sim < 400$  Kpc)
    - Coldwell et al. ang sep  $< 1-3$  Mpc
  - Redshift separation quasar-galaxy
    - $\Delta z < 0.001 = 5$  Mpc ( $\Delta z < \text{Coldwell } 0.0017$ )
    - $\Delta z < 0.006 = 30$  Mpc
    - $\Delta z < 0.012 = 59$  Mpc (1/2 the Photo-z estimation)

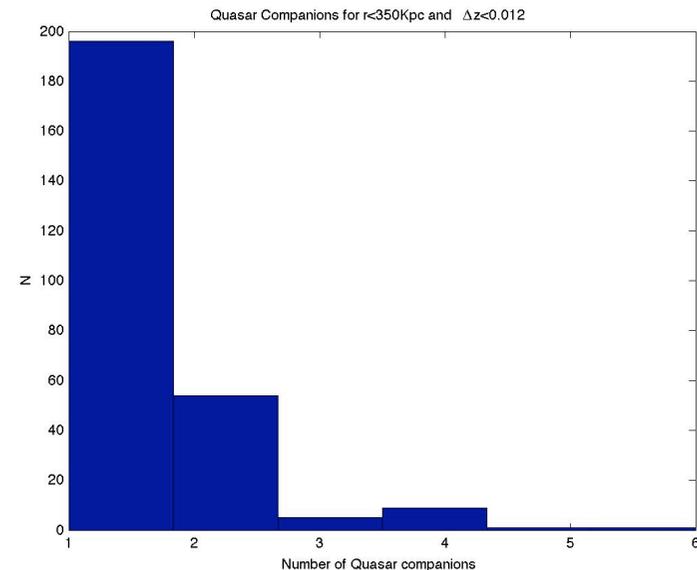
# Angular separation quasar-galaxy

- $0.1 < z < 0.2$  ang sep  $< 7'$  ( $\sim < 400$  Kpc)
- $0.03 < z < 0.1$  ang sep  $< 10'$  ( $\sim < 400$  Kpc)



# Selecting Quasar-Galaxy systems

- 8144 Quasars – Galaxy Pairs
  - $\Delta z < 0.012$  &  $r < 10'$  ( $0.03 < z < 0.1$ ) and  $r < 7'$  ( $0.1 < z < 0.2$ )
- 366 Quasar Systems
  - $\Delta z < 0.012$  and  $r < 350$  Kpc
- 342 Quasar Systems
  - $\Delta z < 0.006$  and  $r < 350$  Kpc
- 221 Quasar Systems
  - $\Delta z < 0.001$  and  $r < 350$  Kpc

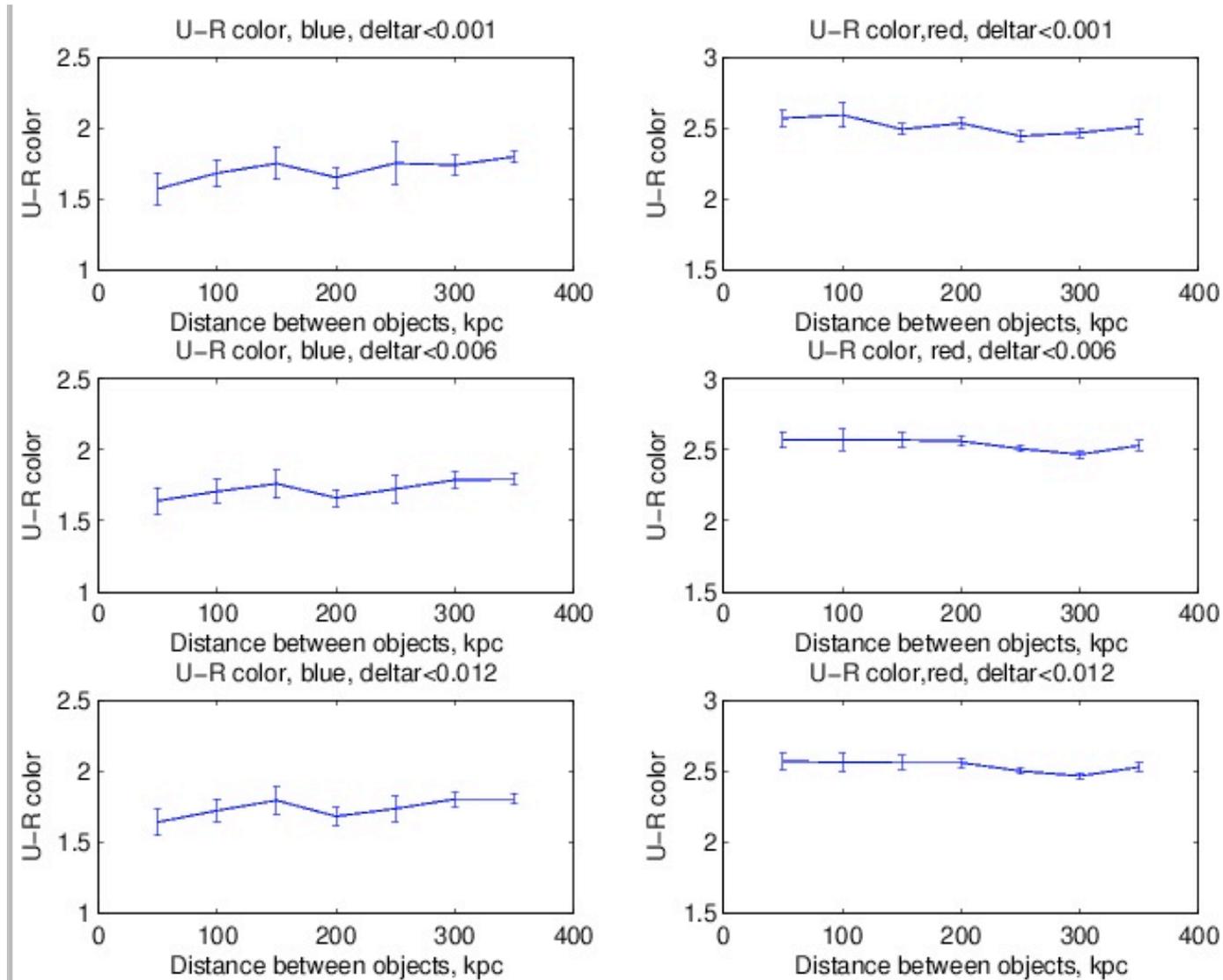


# What would one expect to see?

- The Quasar will clean galaxies of their gas as they approach it?
- The Quasar will stimulate star-formation in galaxies that have gas as they approach?
- We will see different kinds of galaxies at different distances from the Quasar?

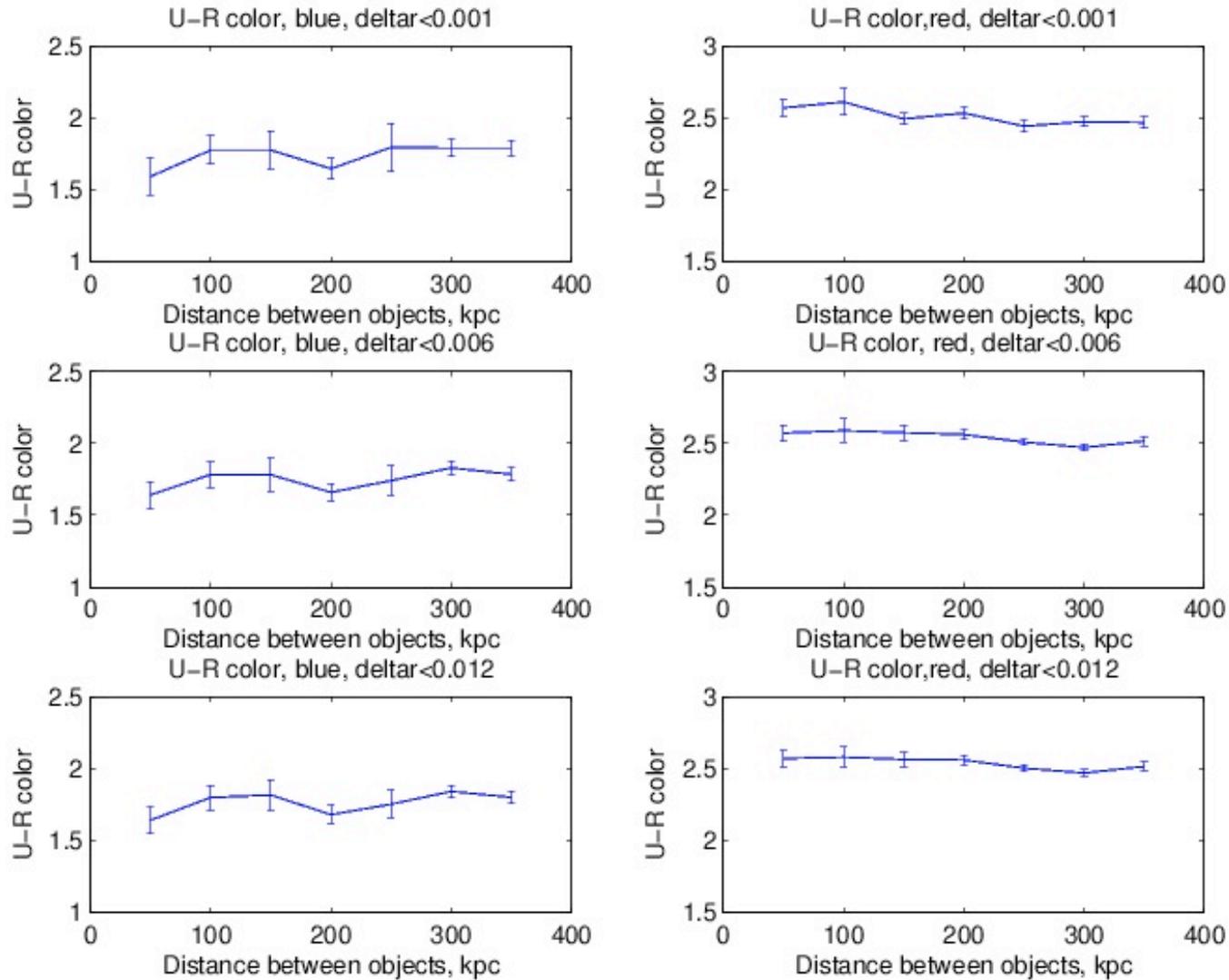
# Effecting Gas content of neighbors?

Fig18 showing, trend for blue not red



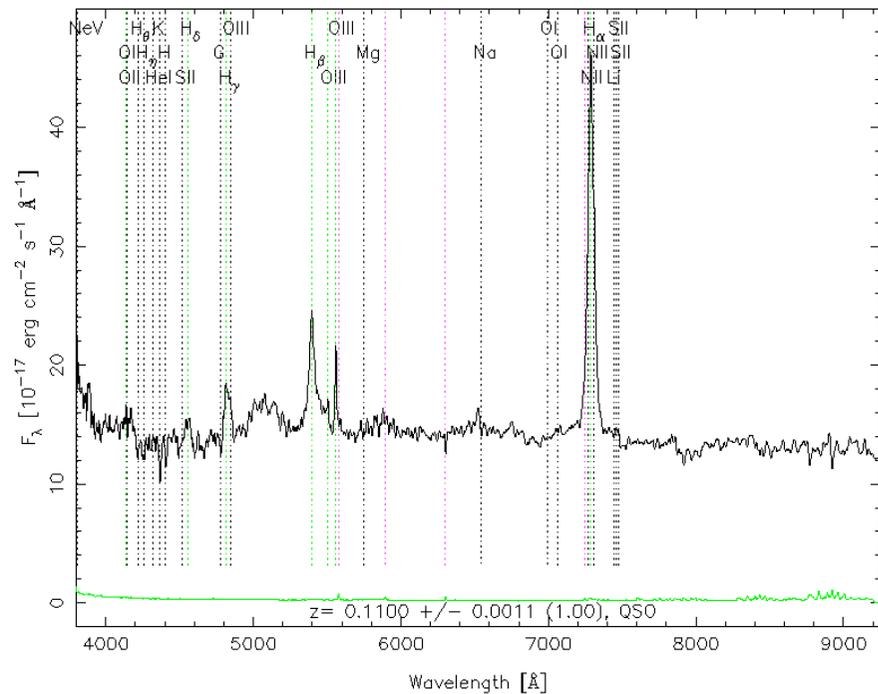
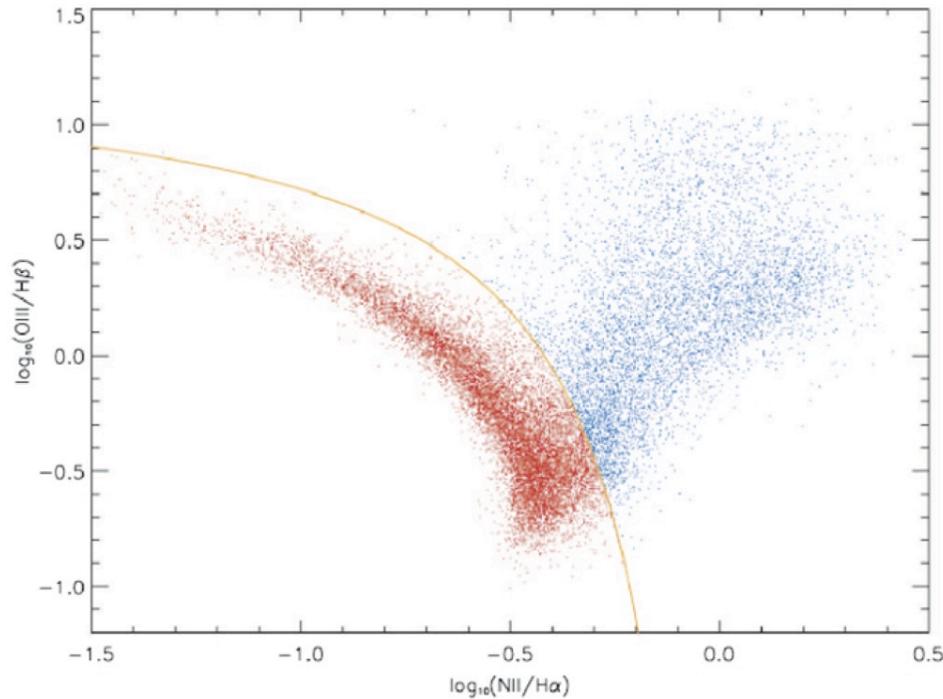
# Effecting Gas content of neighbors?

Fig18 showing, trend for blue(-AGN) not red



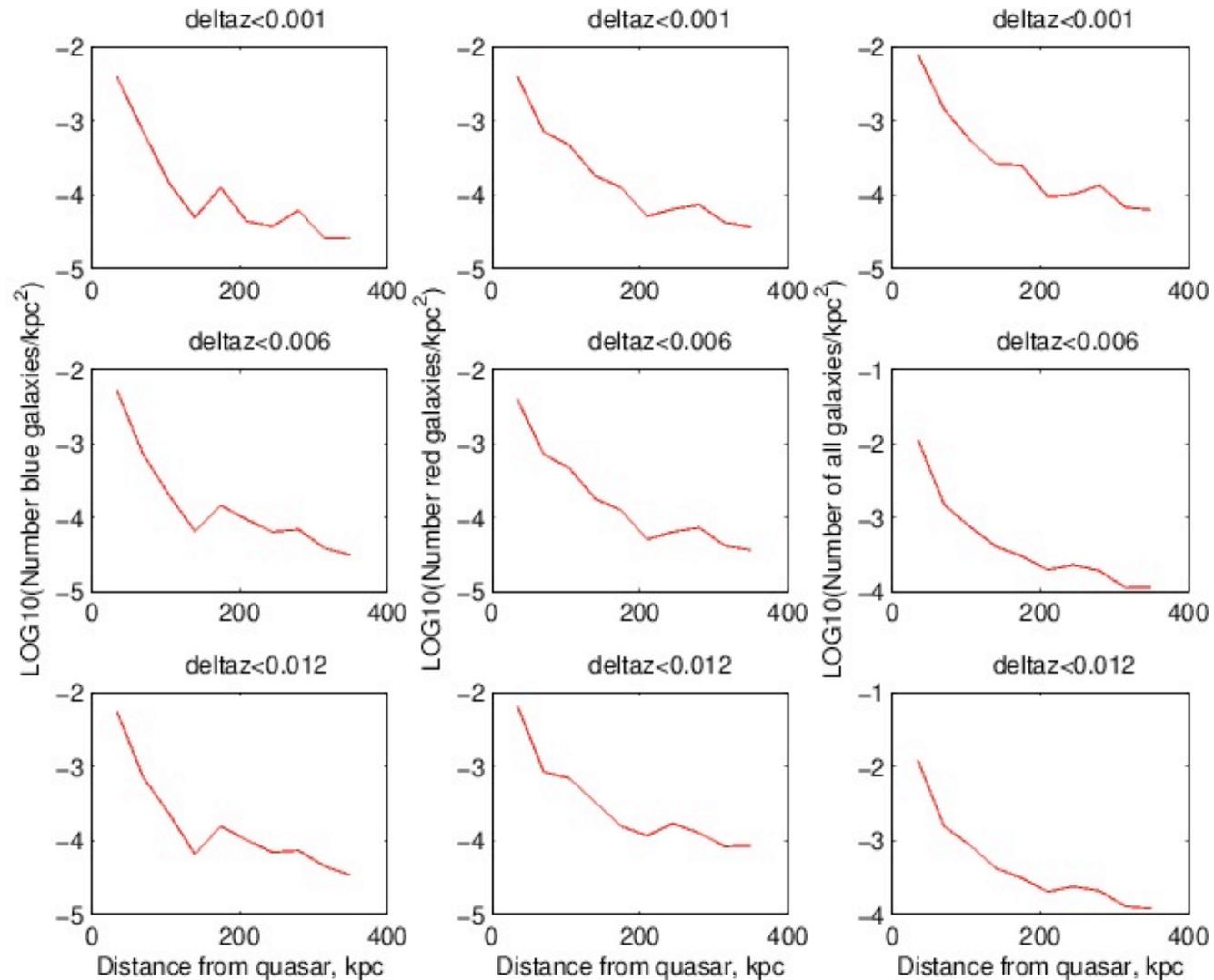
# Distinguishing AGN from HII regions (Star Forming) in blue Galaxies: Why we need spectra

RA=198.11736, DEC= 1.70092, MJD=52295, Plate= 525, Fiber=163



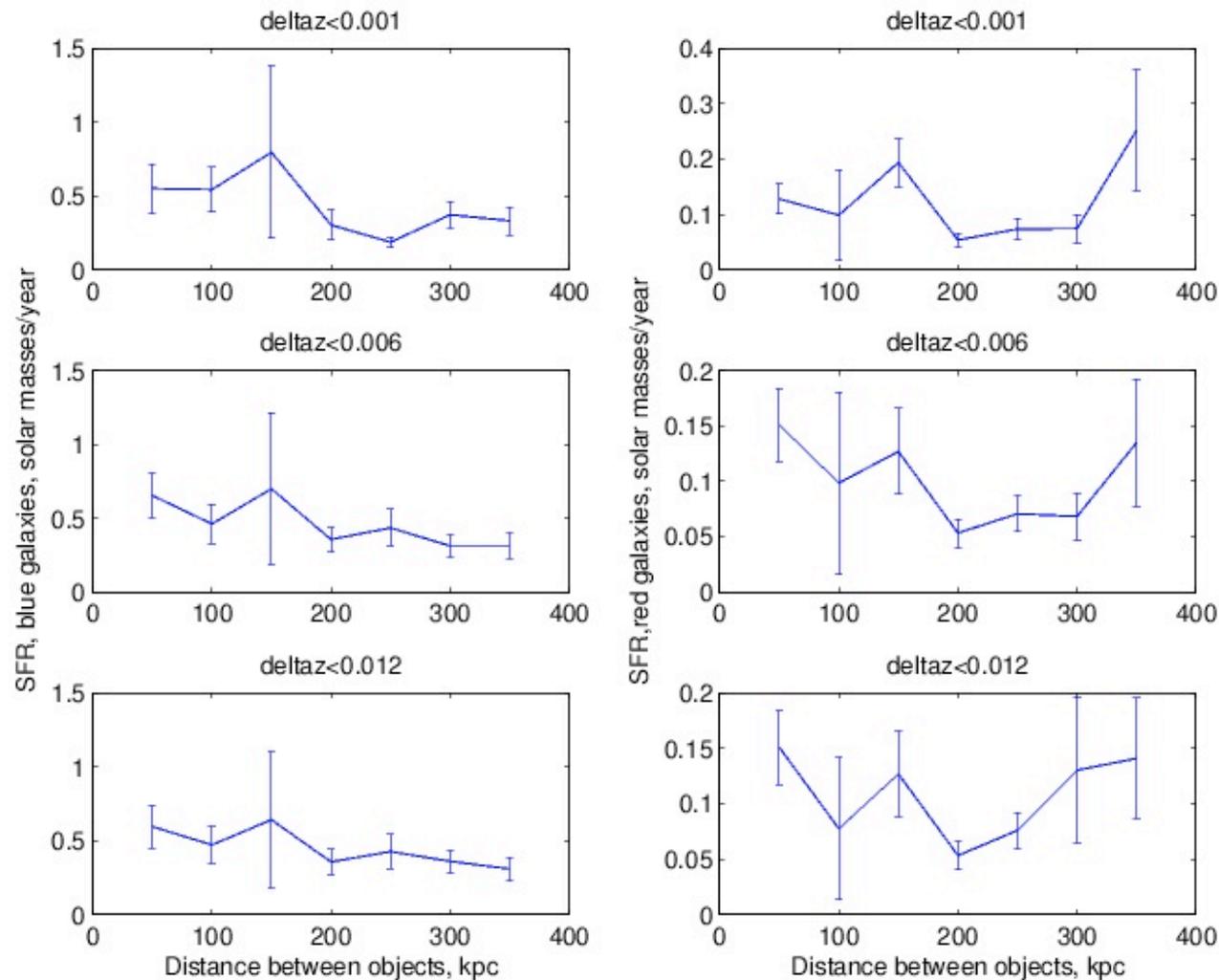
# Effecting Gas content of neighbors?

## Fig2 surface density blue galaxies



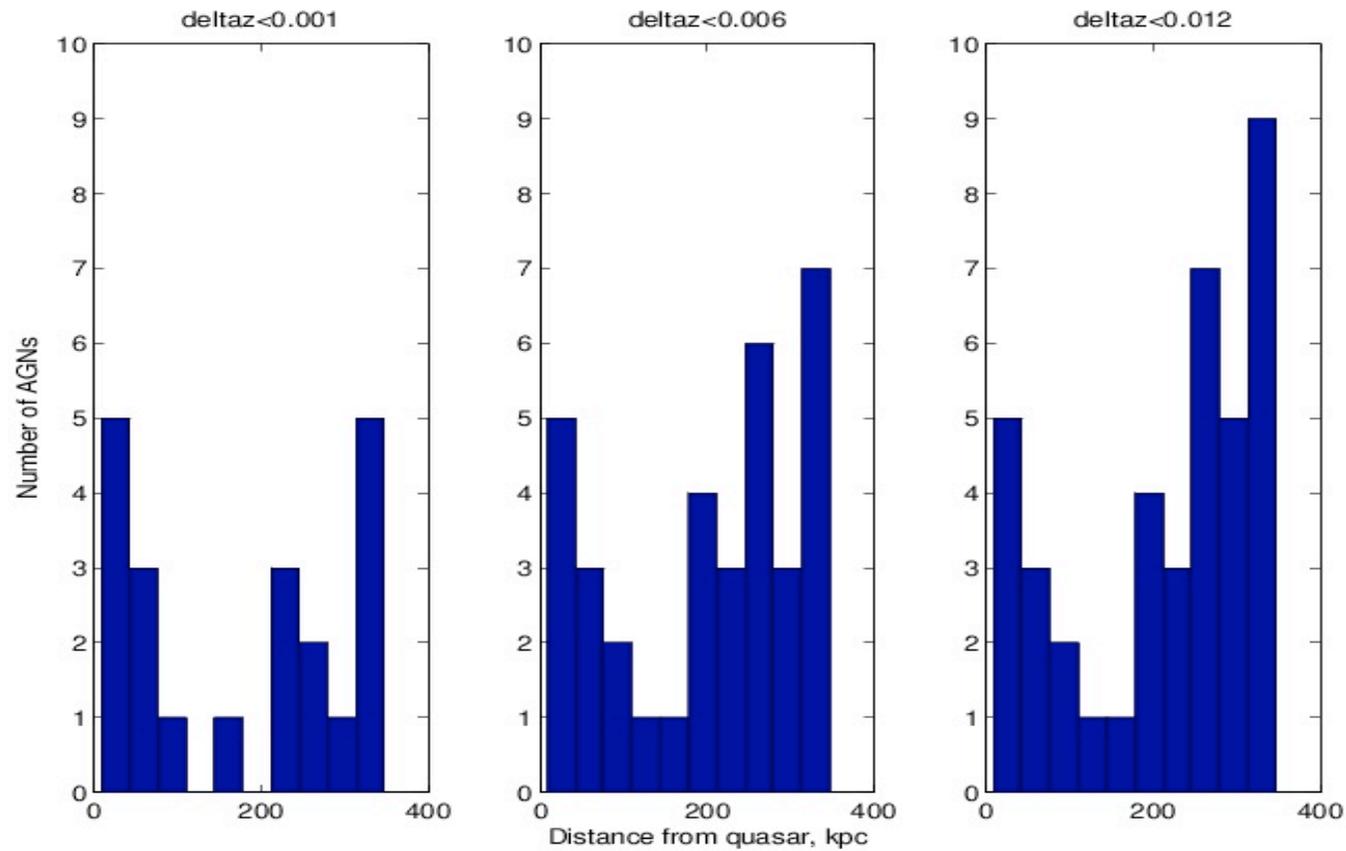
# Quasar Stimulating star-formation?

Fig 17: Star-Formation rate **increases**  $d < 150$  kpc



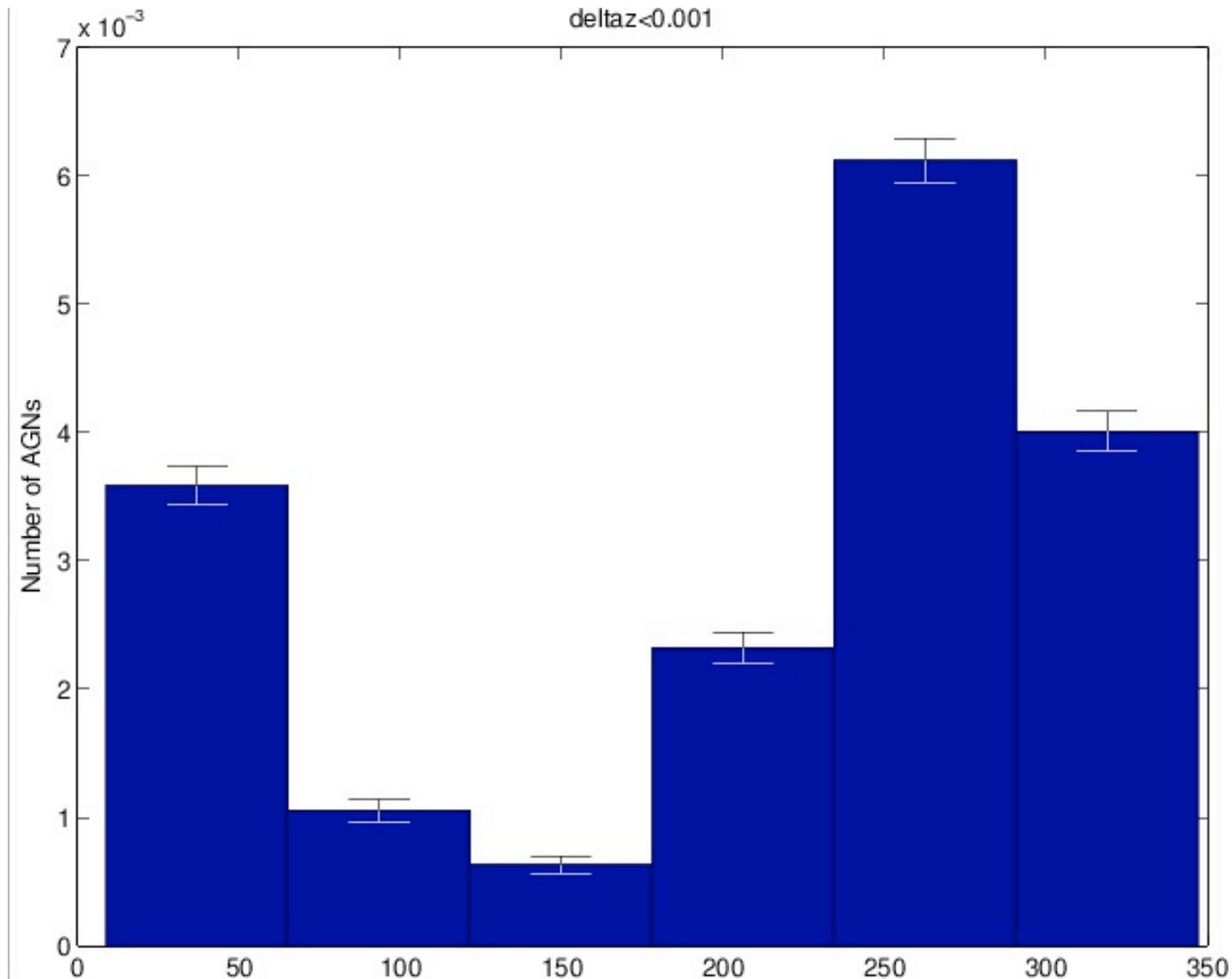
# Different kinds of galaxies at different distances from Quasar?

(fig 12 vs HISTfig24 for AGN vs dist)



# Different kinds of galaxies at different distances from Quasar?

(Optimal Fixed Width binning <http://arxiv.org/abs/physics/0605197> )



# Conclusions?

- We see a difference in the number density of blue (star forming) galaxies in close proximity to Quasars ( $d < 150$  kpc)
- Star-formation rates are higher within 150 kpc
- There appears to be an unexplained gap in the distribution of AGN at 150kpc
- The Quasars ARE effecting their environments, but at much closer radii than previously assumed (150 kpc versus 1000 kpc)

# Future?

- 2dFGRS (get more quasars and galaxies)
- Redo quasar environment queries in SDSS
  - Larger radial distances (1Mpc) to compare with previous work
  - Problem? These queries take a LONG time