Identification of (obscured) AGN in optical surveys

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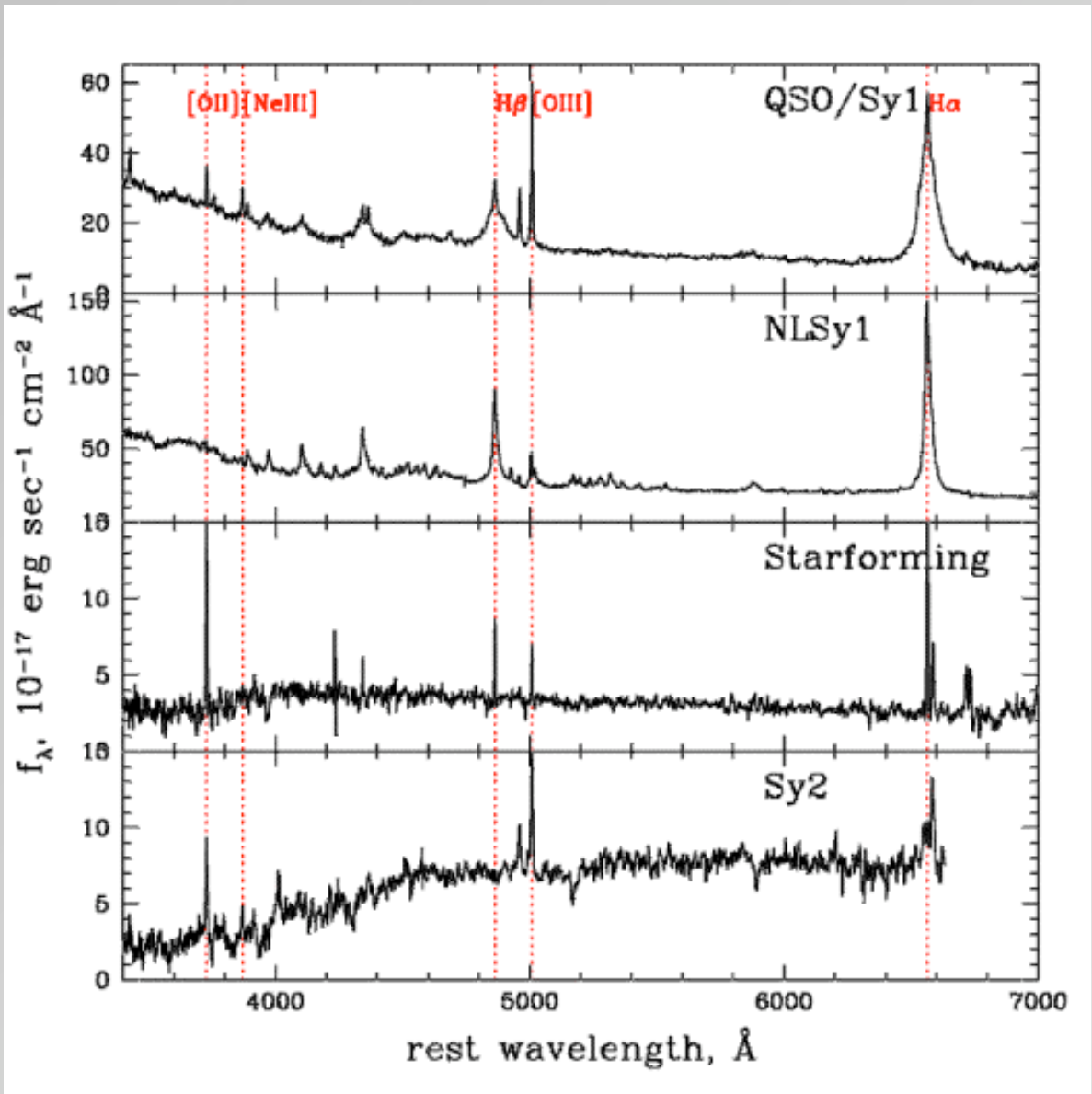
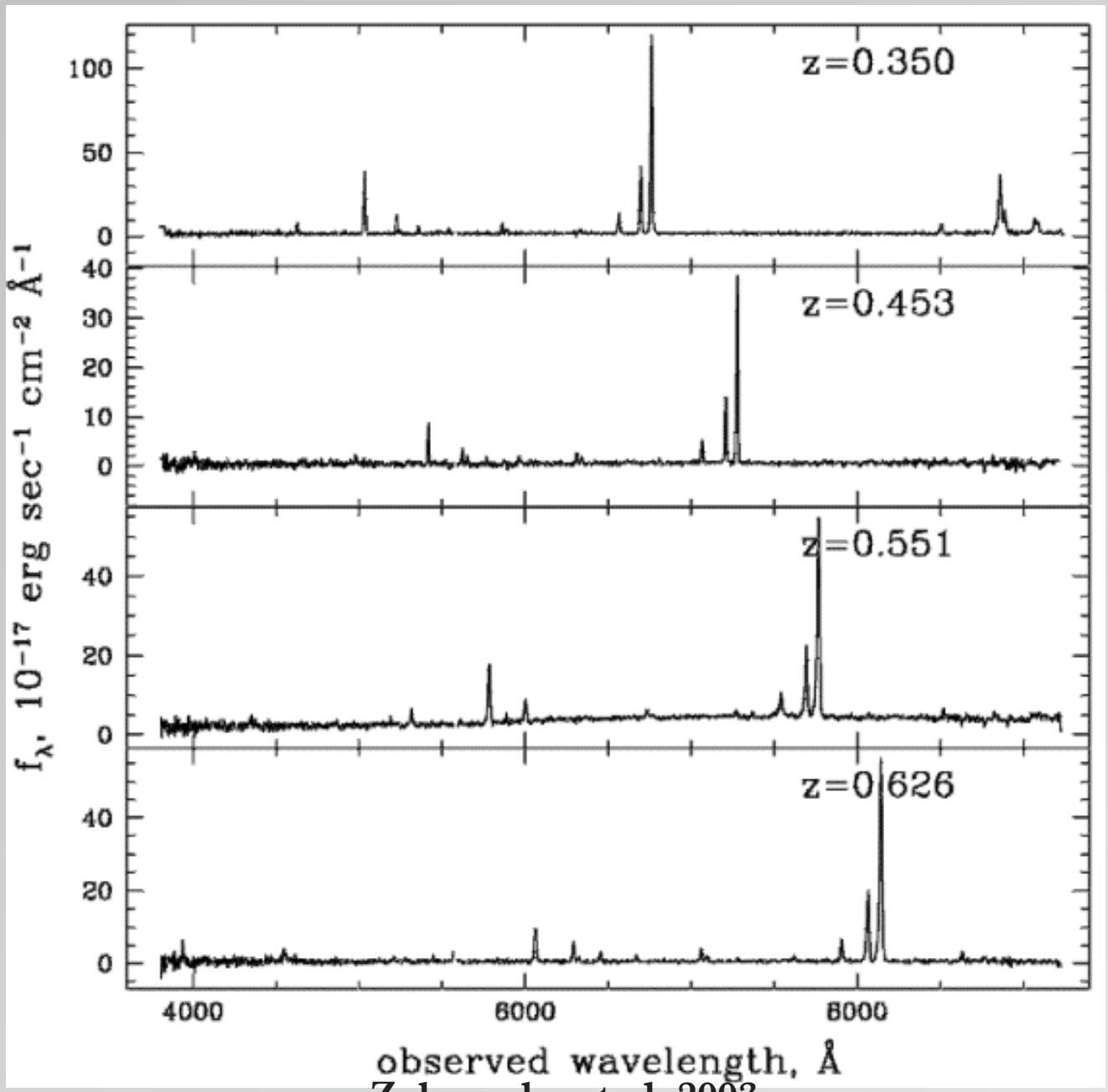
Overview:

1. Selection methods of qso2
2. Multi-wavelength follow-up and testing selection at other wavelengths of qso2
3. AGN census in the optical - in particular, of qso2


[OII]
[NeIII]
Hβ
[OIII]
QSO/Sy1
Hα
NLSy1
Starforming
Sy2
f_λ, 10^{-17} erg sec^{-1} cm^{-2} Å^{-1}
rest wavelength, Å
0
5
10
15
50
100
150
20
40
60
4000
5000
6000
7000



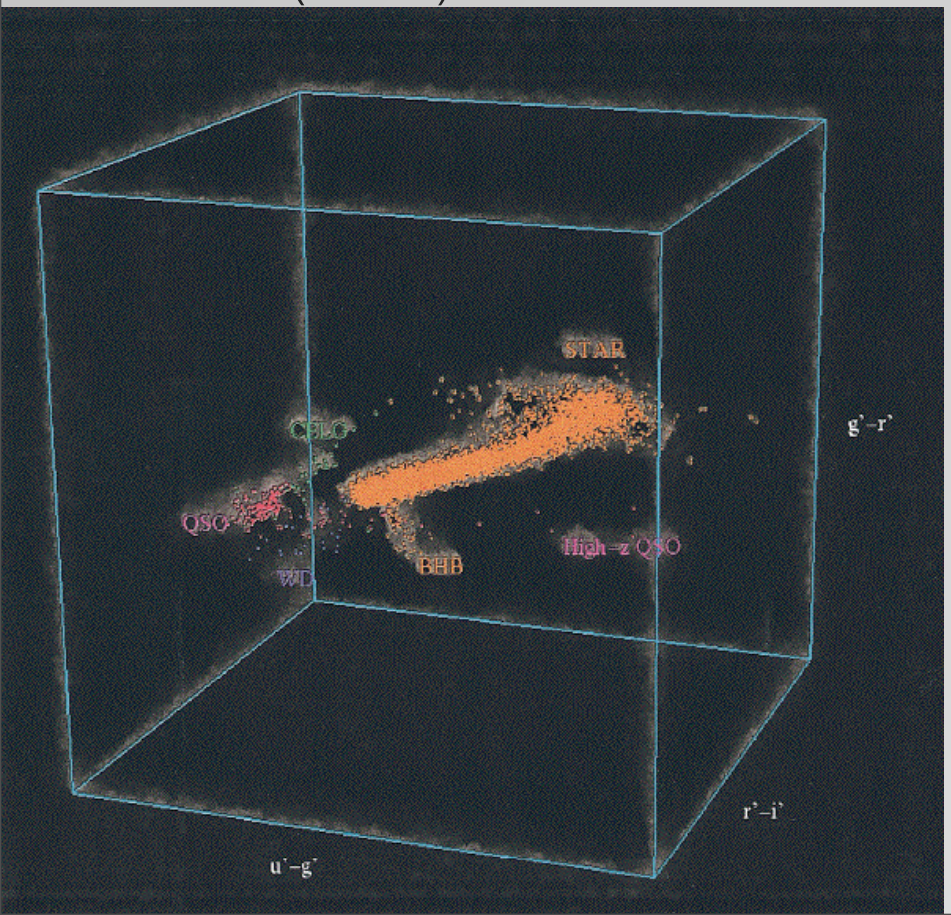
Zakamska et al. 2003

1. Selection methods

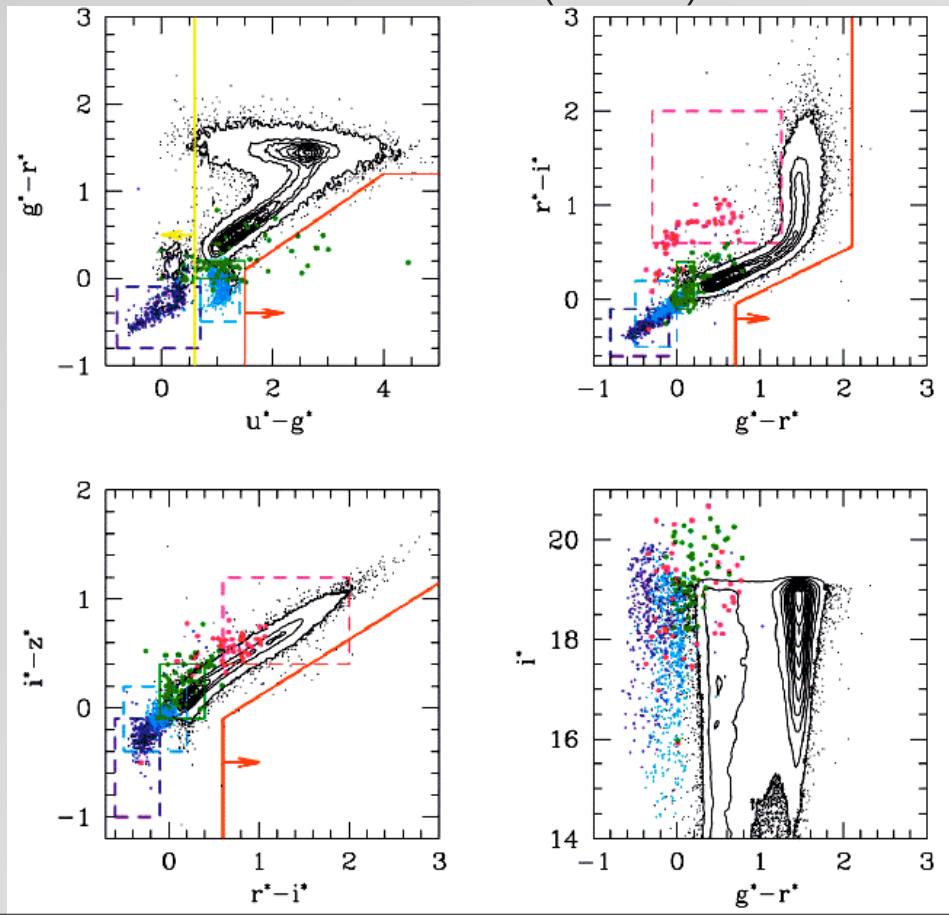
Method 1: colors - quasars are blue [Schmidt & Green 1983 U-B<-0.44]

> The Palomar Bright Quasar Survey (BQS) is a subset of the larger Palomar-Green Survey (PG) of stellar objects with ultraviolet excess. The area surveyed is

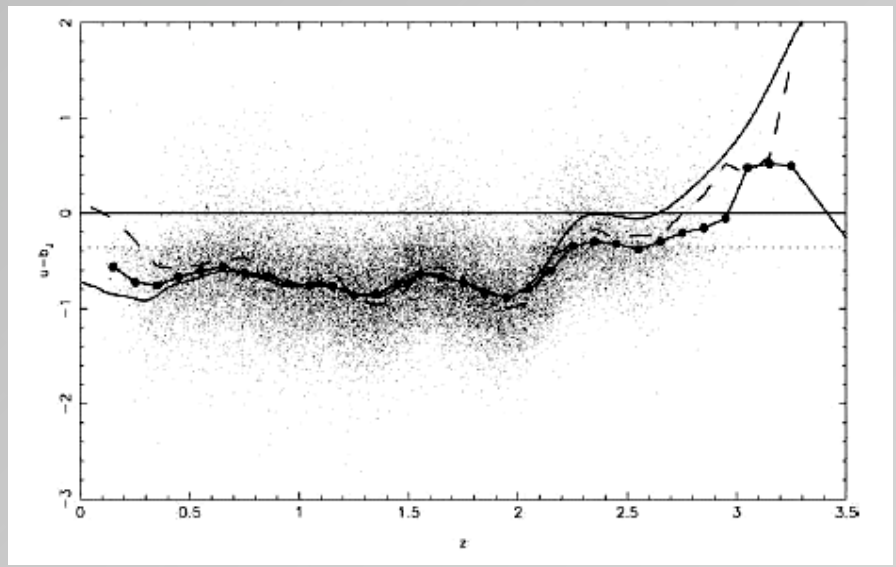
Fan 1999 (SDSS)



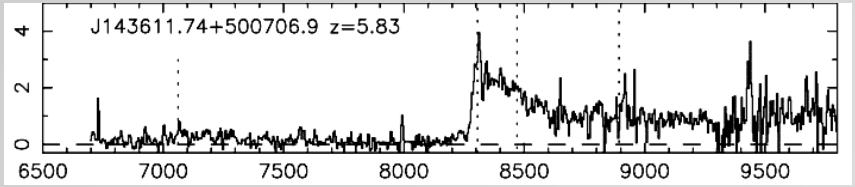
Richards et al. 2002 (SDSS)



1. Selection methods (continued)

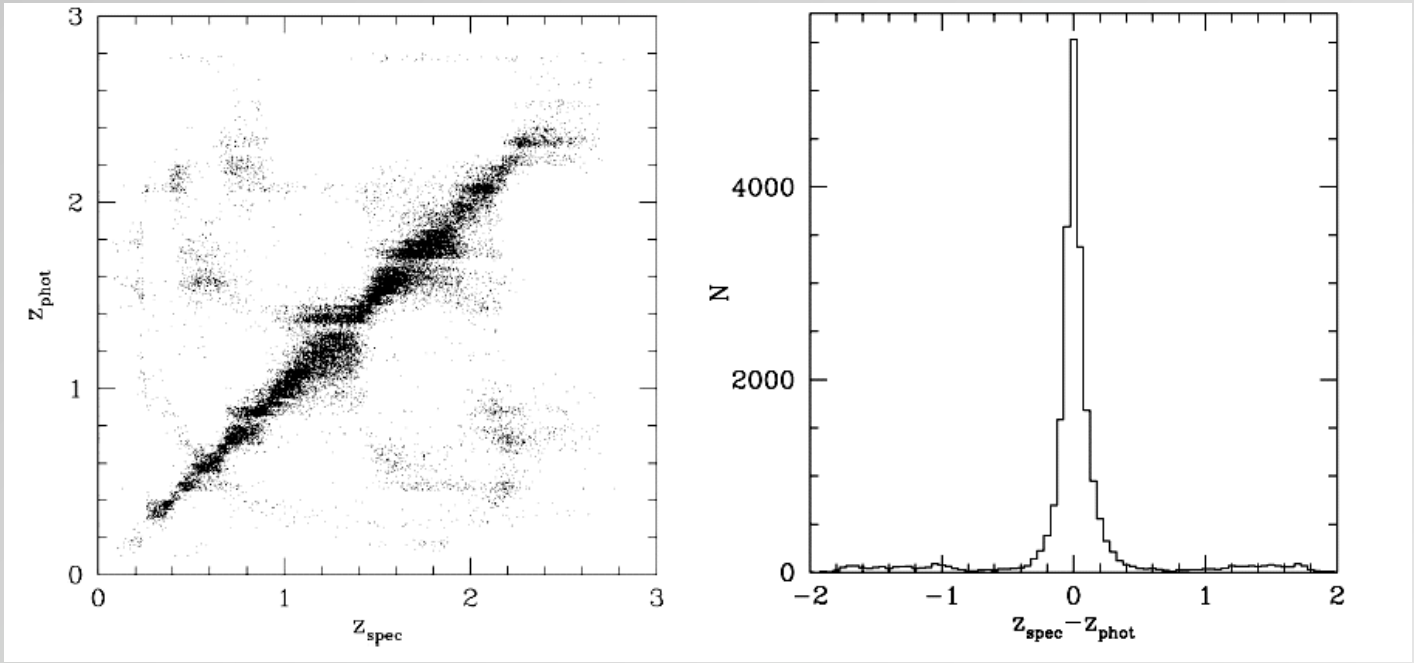


Redshift evolution
[Croom et al. 2004, 2dF]



Fan et al. 2006

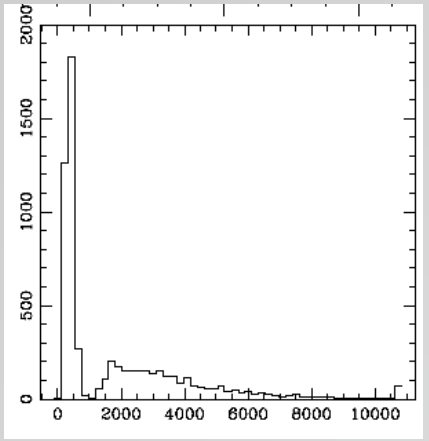
Photometric-only selection
[Richards et al. 2004, SDSS]

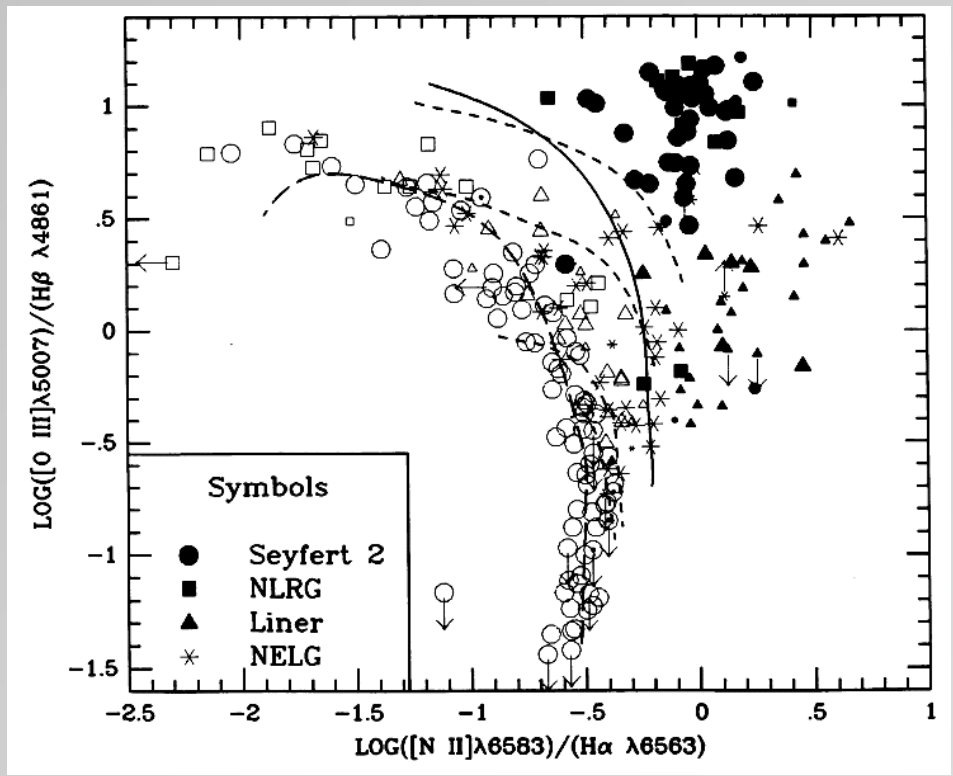


1. Selection methods (continued)

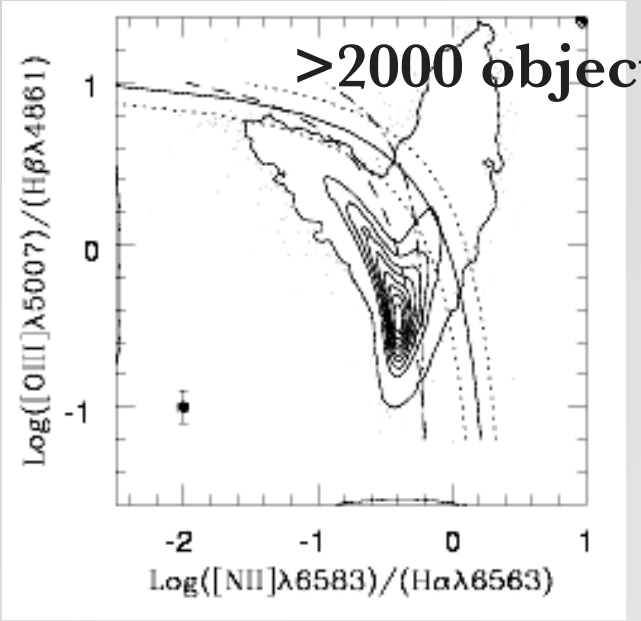
Method 2: galaxies with emission lines

- broad vs narrow (FWHM=1100 km/s, Hao et al. 2005),
- high-ionization vs low-ionization





Veilleux & Osterbrock 1987



Kauffmann et al. 2003,
Hao et al. 2005,
Groves et al. 2006 (SDSS)

1. Selection methods (continued)

Type II quasars: problems with a parent sample

Spectrum=host+em. lines+scattered light. Non-quasar colors

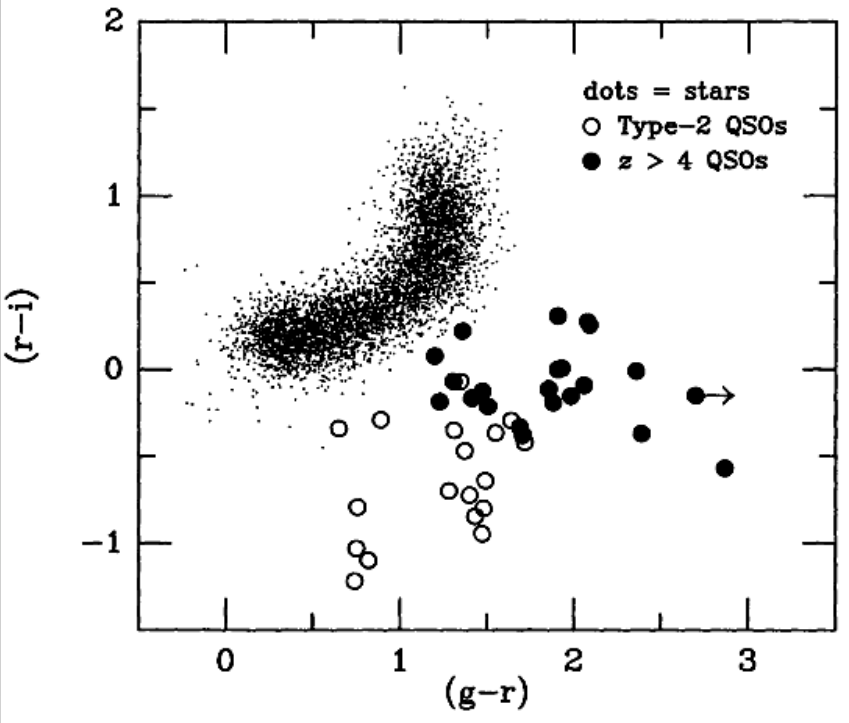
Rare at low redshifts, too far to be resolved

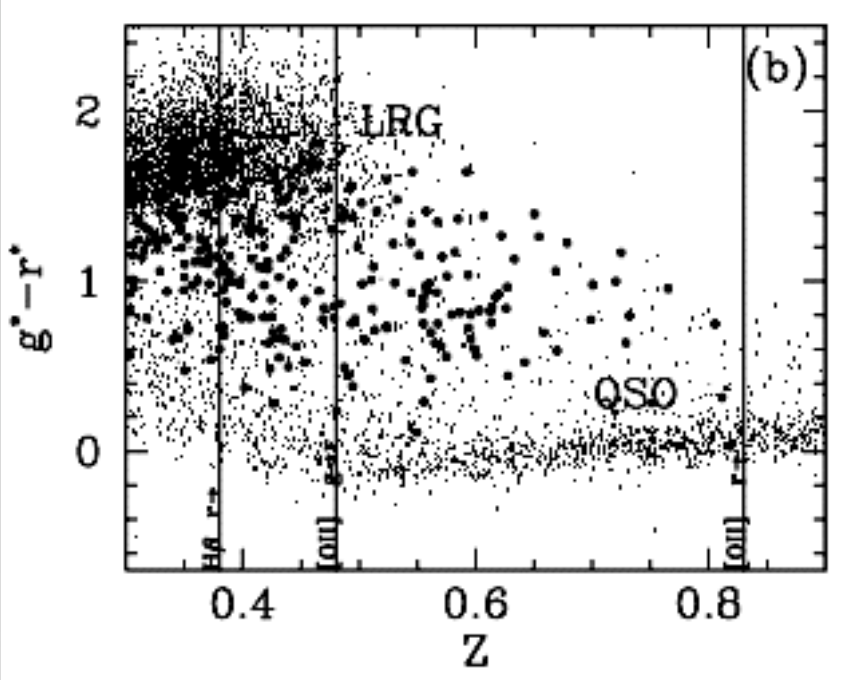
Intrinsically faint in the optical

Look for objects with unusual colors?

[Djorgovski et al. 2001, DPSS]

[Zakamska et al. 2003, SDSS]





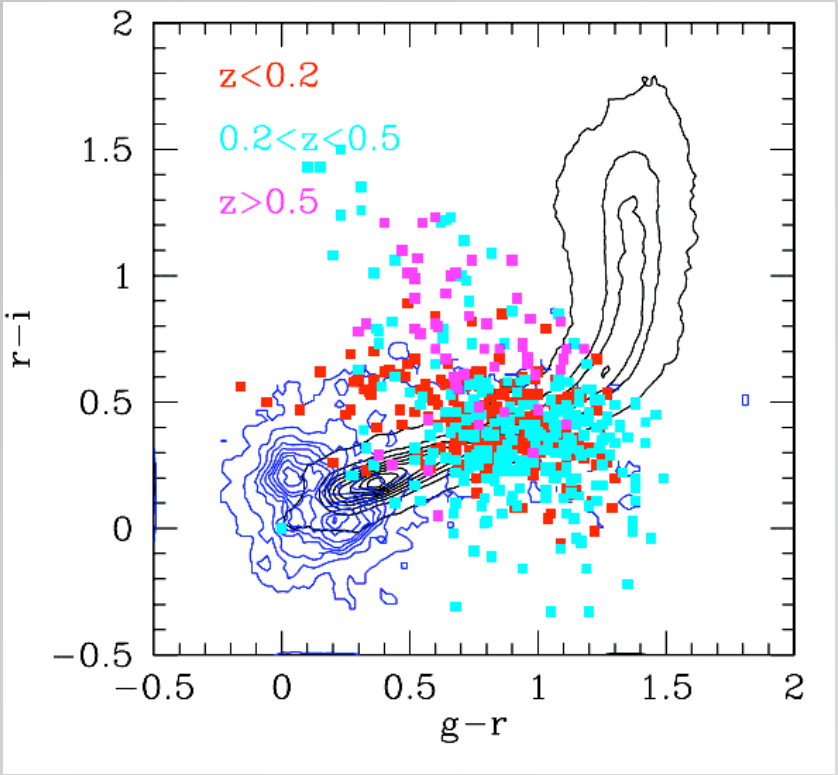
1. Selection methods (continued)

Type II quasars:

Spectra of everything (based on colors, morphologies, multi-wavelength properties)

[problems near stellar locus]

Selection based on emission lines



Reyes,
Zakamska,
Strauss, et al.
in preparation

900 type II AGN
>600 type II quasars

Prospects for high-z type II AGN:

- UV lines: fewer, fainter
- Theory still works
- Broad vs narrow line AGN - ?
- A handful in SDSS

2. Multi-wavelength follow-up

Do different methods select the same populations of objects?

Optical definition: narrow vs broad lines, M_B=-23 or [OIII] luminosity criterion

X-ray definition: $N_H=10^{22}$ cm^{-2}, $L_{2-10}=10^{44}$ erg/s

Mid-IR: Si absorption. Far-IR: isotropic, $L_{bol}=10^{45}$ erg/s

Unification model: significant population of AGN in which

- **Classifications agree**
- **Narrow lines = X-ray obscuration**
- **Detected in IR**
- **Correlation between optical / IR / X-ray luminosities -> the concept of average spectral energy distribution**

However, tens of per cent for which classifications disagree (or impossible to confirm)

Even if agree, dispersion in properties -> selection biases:

Optical selection - optically bright objects

X-ray selection - X-ray bright objects

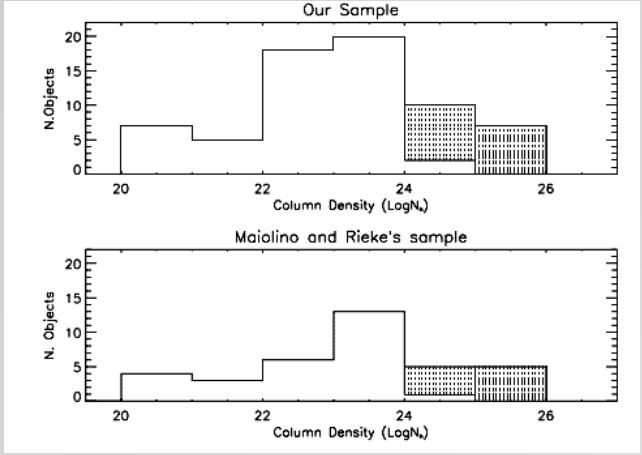
2. Multi-wavelength follow-up

Optical vs X-rays - Seyfert 2

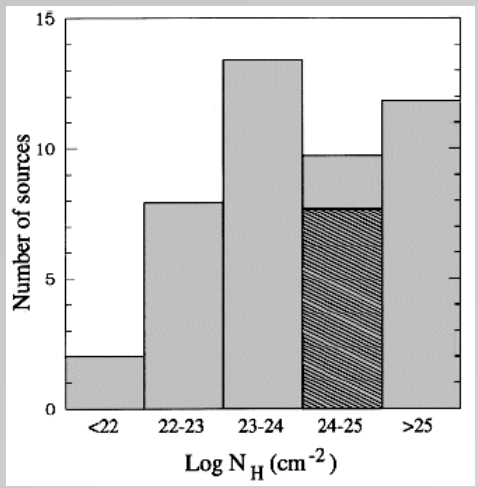
- Column densities

25%-70%>10^{24} cm^{-2}

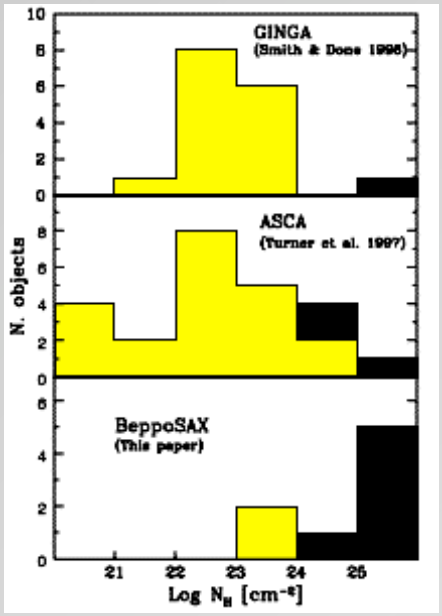
- X-ray / optical ratio

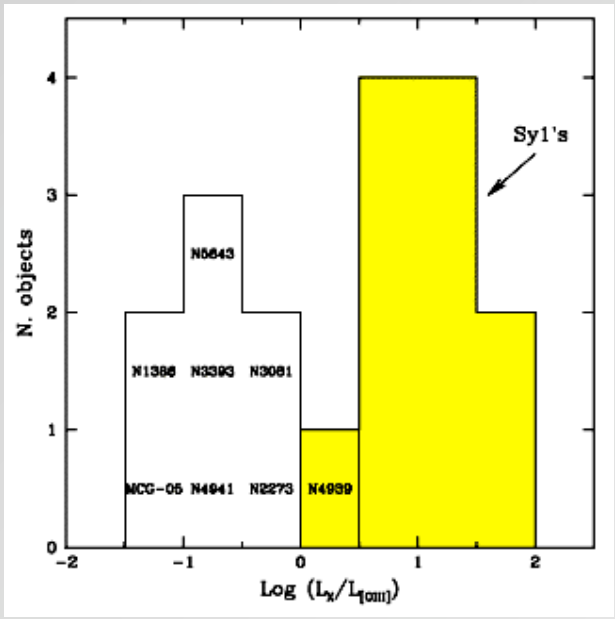


Bassani et al. 1999



Risaliti et al. 1999 (optical selection based on [OIII] flux)



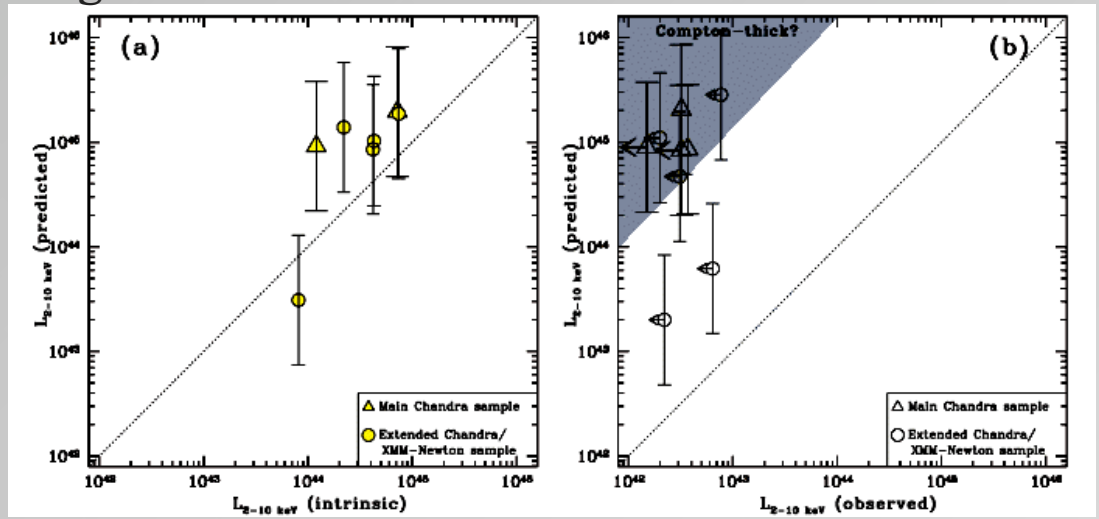


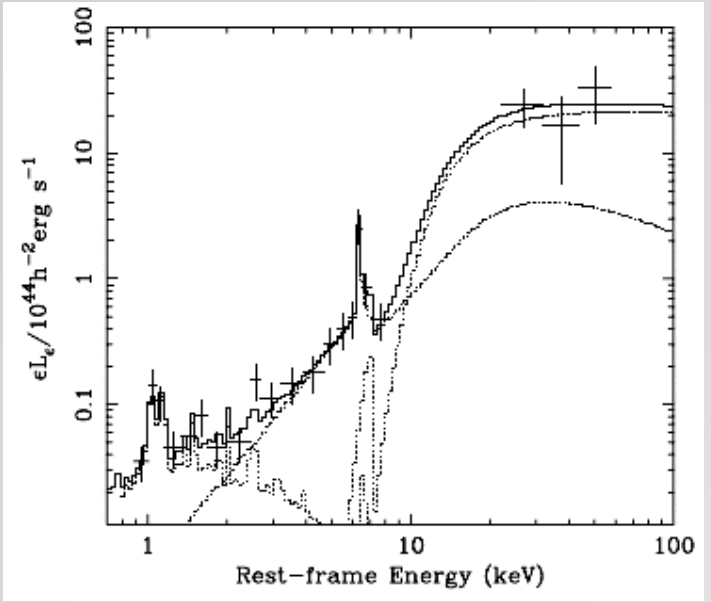
Maiolino et al 1998

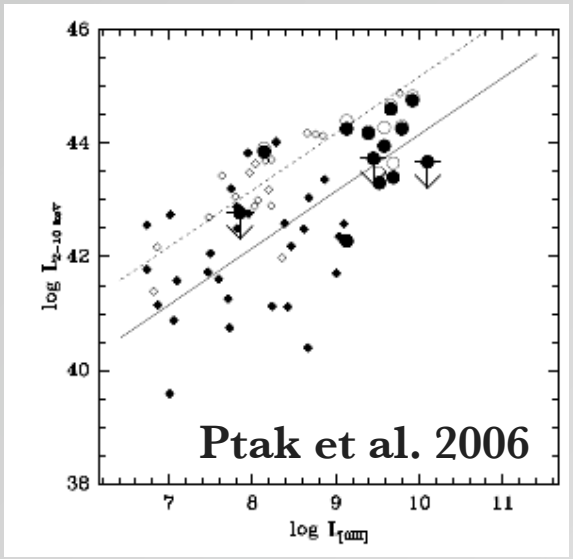
2. Multi-wavelength follow-up

Optical vs X-rays - type 2 quasars (Zakamska et al. 2003)

Vignali et al. 2006







[Iwasawa et al. 2001]
IRAS 09104
Selected as high IR/optical
The most [OIII]-luminous quasar known
$L_X > 10^{46}$ erg/sec

2. Multi-wavelength follow-up

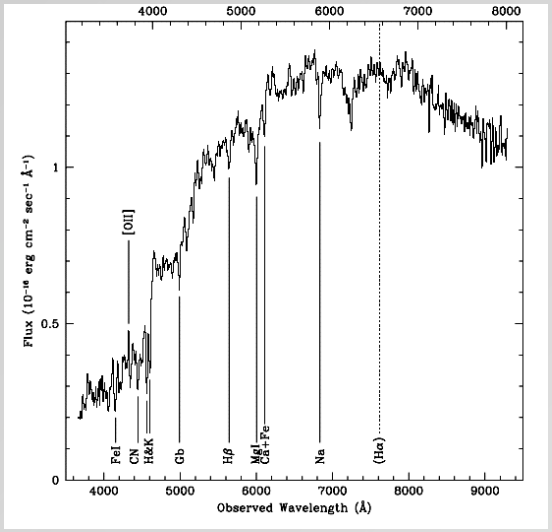
X-ray selected objects:

X-ray bright - optically normal galaxies

TABLE 5

SPECTRAL CLASSES FOR THE A370, CDF-N, AND SSA 13 2–7 keV SAMPLES

Class	A370	CDF-N	SSA 13	Summed
Broad line	4	4	2	10
High ionization	3	7	5	15
"Normal"	5	9	6	20
Unidentified $I \leq 23.5$.....	3	4	0	7
Unidentified $I > 23.5$.....	0	10	7	17



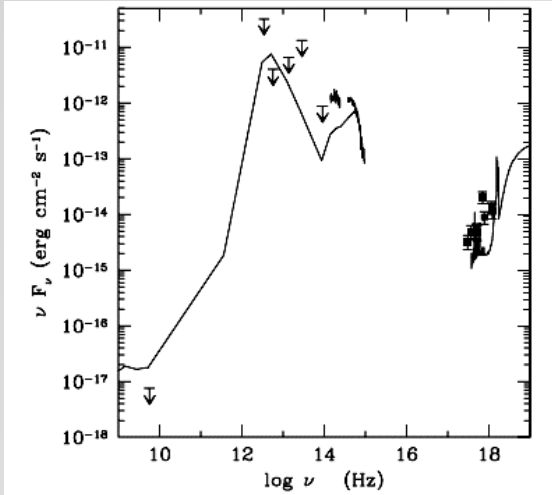


FIG. 5.—Observed SED is compared with that of the highly obscured Seyfert 2 galaxy NGC 6240.

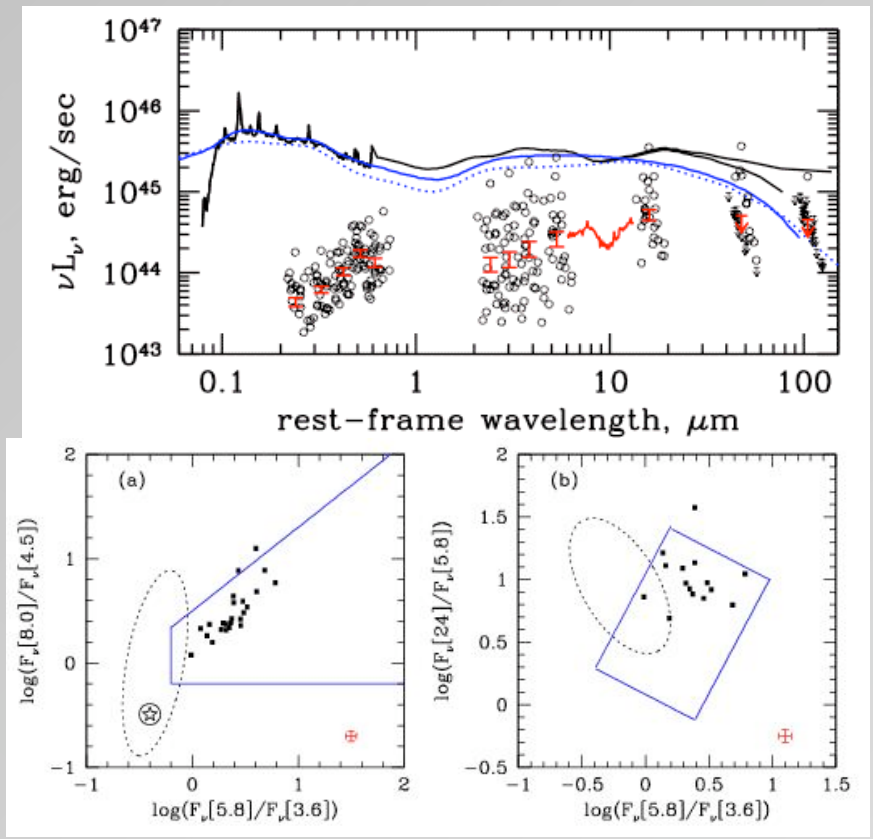
Comastri et al. 2002

Best fit: Compton-thick AGN, 10^{44} erg/sec

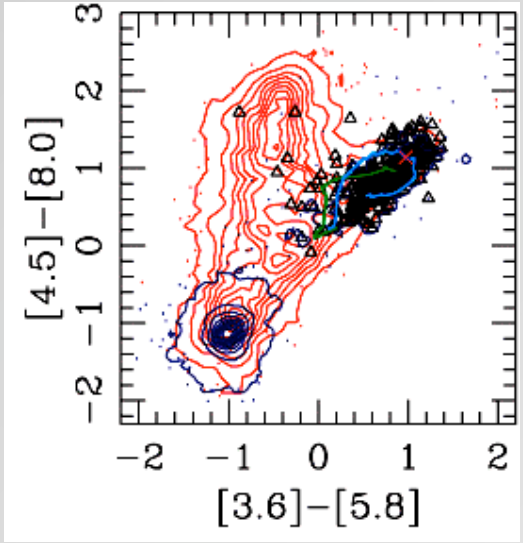
2. Multi-wavelength follow-up

Optical vs IR:

- **All AGN seem to be IR bright -> there is dust in type I quasars**
- **IR selection: good, but not perfect (Stern et al. 2005: 60% of NL)**
- **Use optically selected AGN to test IR selection, also at high z**



Zakamska et al., in prep.
[comparison with color selection
by Lacy et al. 2004, Stern et al. 2005]

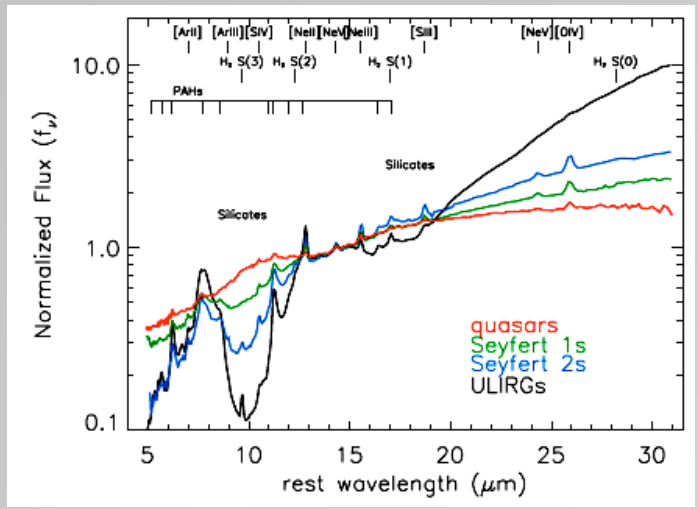


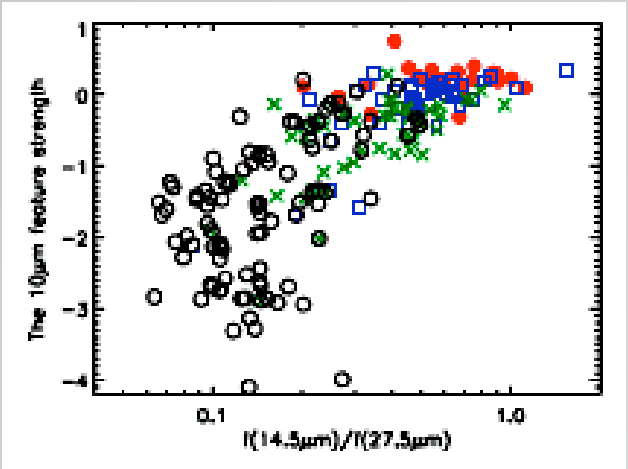
Richards et al. 2006

2. Multi-wavelength follow-up

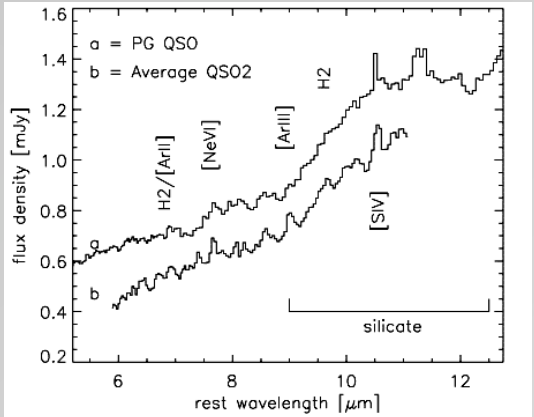
Optical vs IR vs X-rays:

Appearance of 10 micron Si feature

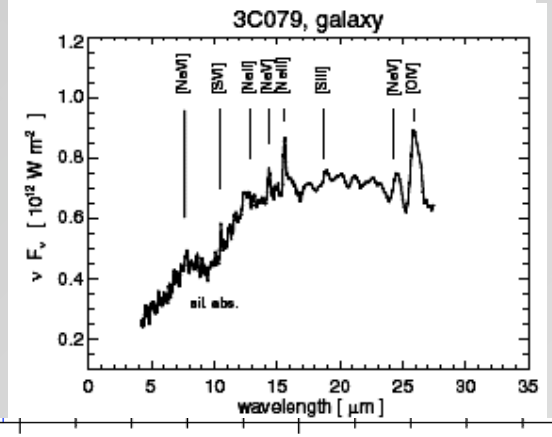




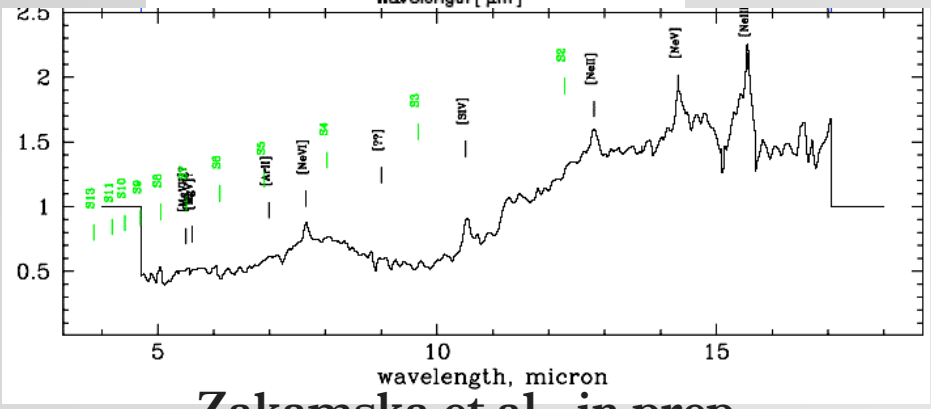
Hao et al. 2007



Sturm et al. 2006
(X-ray selected)



Haas et al. 2005
(radio galaxies)



Zakamska et al., in prep.
(optical type II quasars)

3. Optical luminosity function

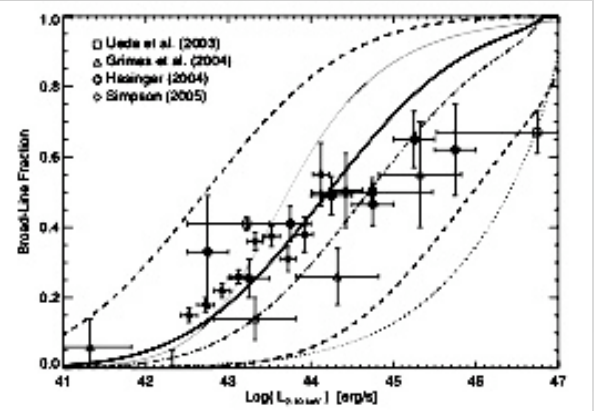
Goals:

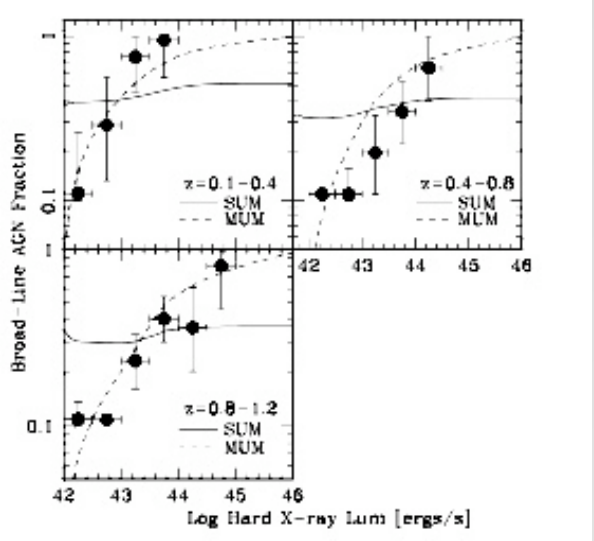
Density of obscured AGN

Density of unobscured AGN

As a function of luminosity

As a function of redshift





High luminosities, high redshifts: controversial

X-rays & multi-wavelength:

Obscured fraction drops with X-ray luminosity?

IR (Spitzer): type II / type I > 1?

(Stern et al. 2005, Martinez-Sansigre et al. 2006, Lacy et al. 2006)

Treister et al. 2006 (GOODS)
Brusa et al. 2007 (COSMOS)
Sazonov & Revnivtsev 2004 (RXTE)

3. Optical luminosity function

Optical: what is luminosity?

Type 1 quasars: M_B

Low-luminosity AGN - galaxy dominated

Low luminosity, low redshift:

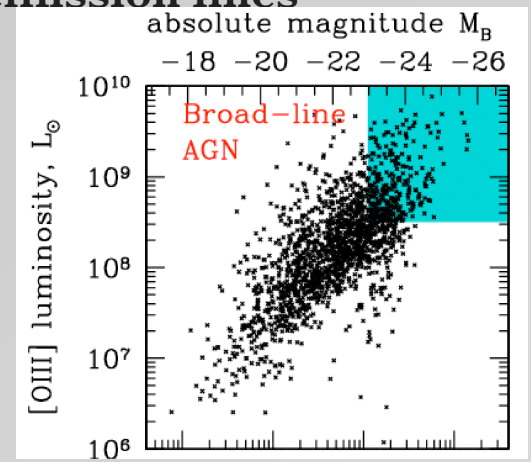
Seyfert 2 galaxies dominate

Osterbrock & Shaw 1988 4:1

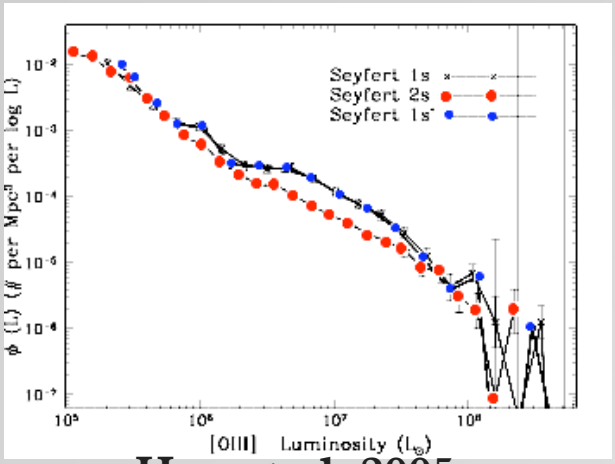
Salzer 1989 5:1

Huchra & Burg 1992 2:1

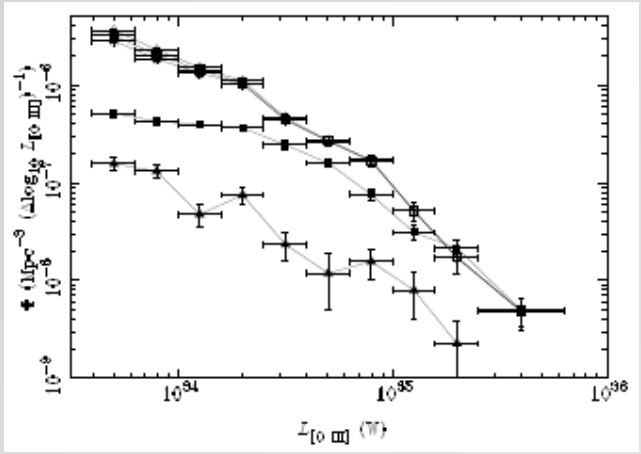
Luminosity indicator: use narrow emission lines



Zakamska et al. 2003



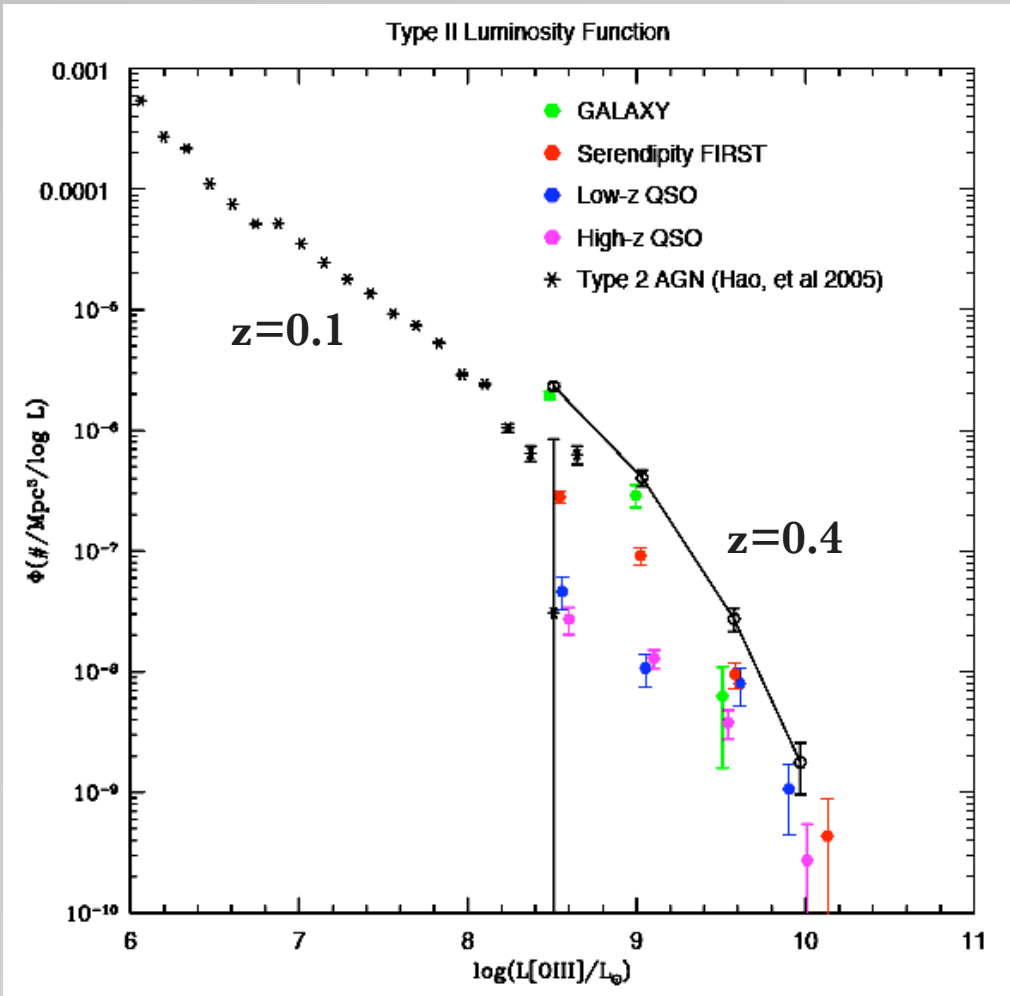
Hao et al. 2005



Simpson 2005

3. Optical luminosity function

LF of SDSS type II quasars:



Reyes, Zakamska, Strauss, et al., in prep.

- Based on 700 objects
- Complicated selection function
- Redshift evolution (bins; <V/Vmax> test)
- Type II/Type I ratio comparable to or greater than 1
- Our LF is a lower limit

- **Optical selection of AGN:** very well developed (colors, line diagnostic diagrams)
- Optical definitions (broad vs narrow, high vs low excitation) serve as "verification"

- Optical selection of type II quasars: "take spectra of everything" method
- Hundreds of optically selected type II quasars

- Different methods select different samples
- Typical overlap: tens of per cent

- **Current goals:** census of type II population
- As a function of luminosity, redshift
- [5 years ago: about ten objects published at all wavelengths]
- Optically selected type II quasars: although selection is complicated, provide an independent measurement
- Suggest no significant decline in type II / type I ratio