Evolution of AGN - Optical View

Bonn, 30 Sep 2004

Christian Wolf, Oxford

Discovery of Quasars

- Schmidt 1968,1970
  - Sharp decline from z=2 to z=0
  - Visible in samples of 20 objects
  - Radio and optical selection
  - V/V_{max} test

TABLE 1

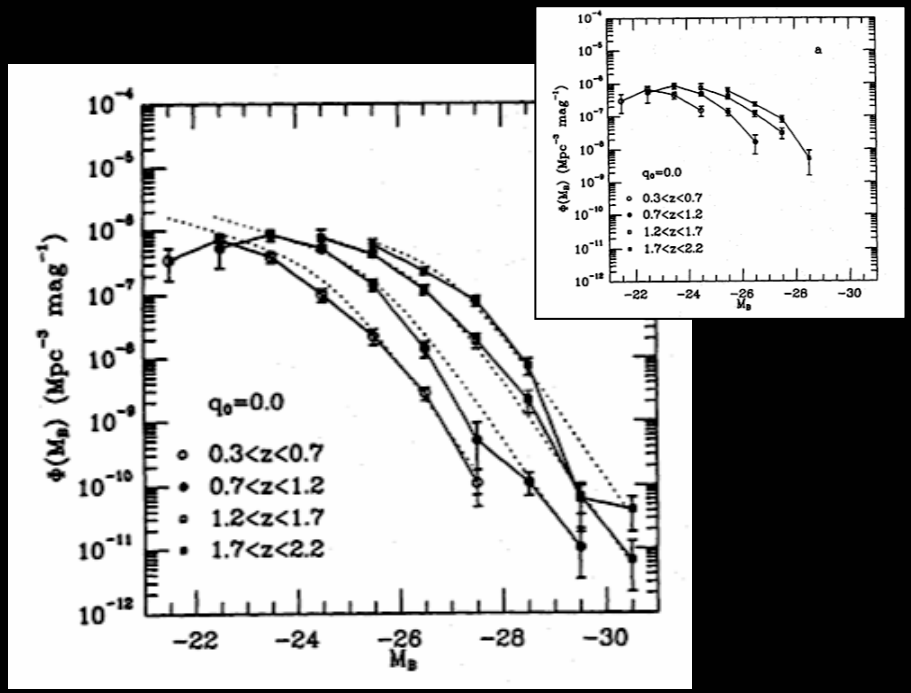
DISTRIBUTION OF REDSHIFTS OF SANDAGE-LUYTEN QSOs AND 3CR QSSs OF APPROXIMATE OPTICAL MAGNITUDE 18 ($-30.0 \log < f_{opt} < -29.6$)

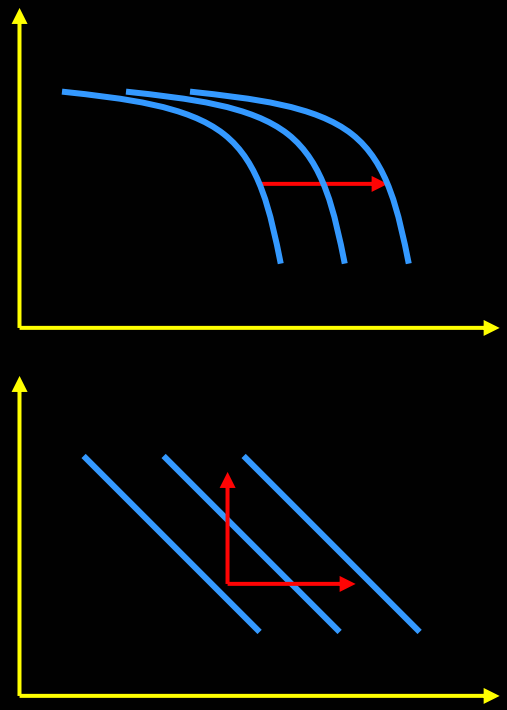
log z	QSOs	3CR	Adopted Fractional
+0.2 to +0.4	5	3	0.20
0.0 to +0.2	7	6	0.35
−0.2 to 0.0	2	6	0.20
−0.4 to −0.2	3	2	0.15
−0.6 to −0.4	0	1	0.05
−0.8 to −0.6	2	0	0.05
Unknown	1	1	
Total	20	19	1.00

Observational Definition

- Optical perspective:
  AGN =
  - Non-stellar continuum radiation
    (SF may be occurring in vicinity, common trigger?)
  - M_B= -10…-30 (QSO = high-L, not obscured)
- Working hypothesis:
  AGN =
  - Powered by accretion onto massive Black Holes
  - Live in host galaxies

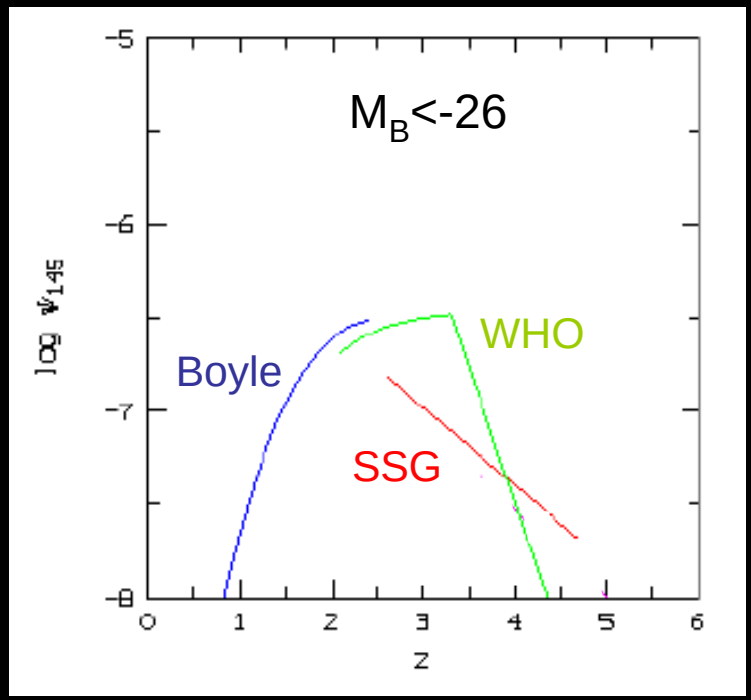
5 Years Ago - LF Evolution

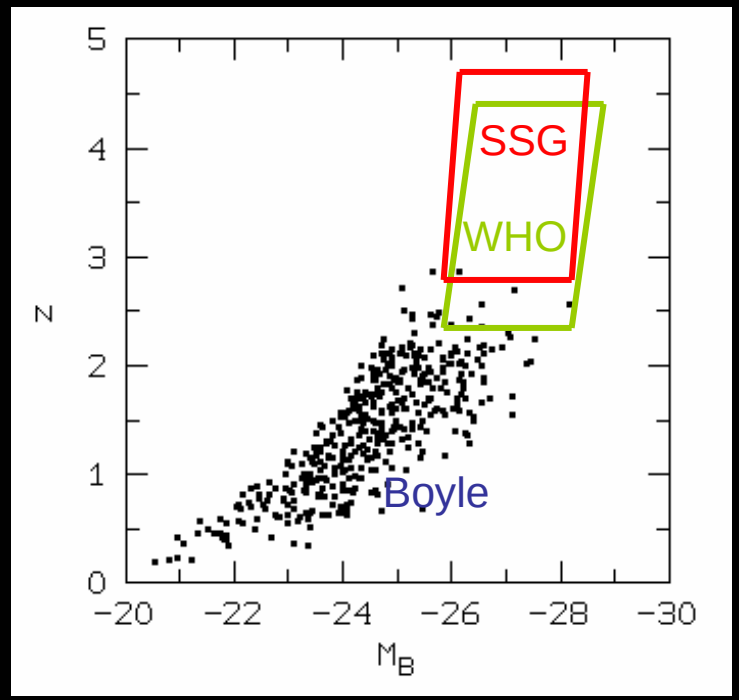




- *Boyle, Shanks & Peterson 1988:* PLE
- *Warren, Hewitt & Osmer 1994:* complicated description
- *Schmidt, Schneider & Gunn 1995:* linear function

5 Years Ago - Ψ and Samples





- Rise & Fall established
- High-z debate
- Selection, details unclear

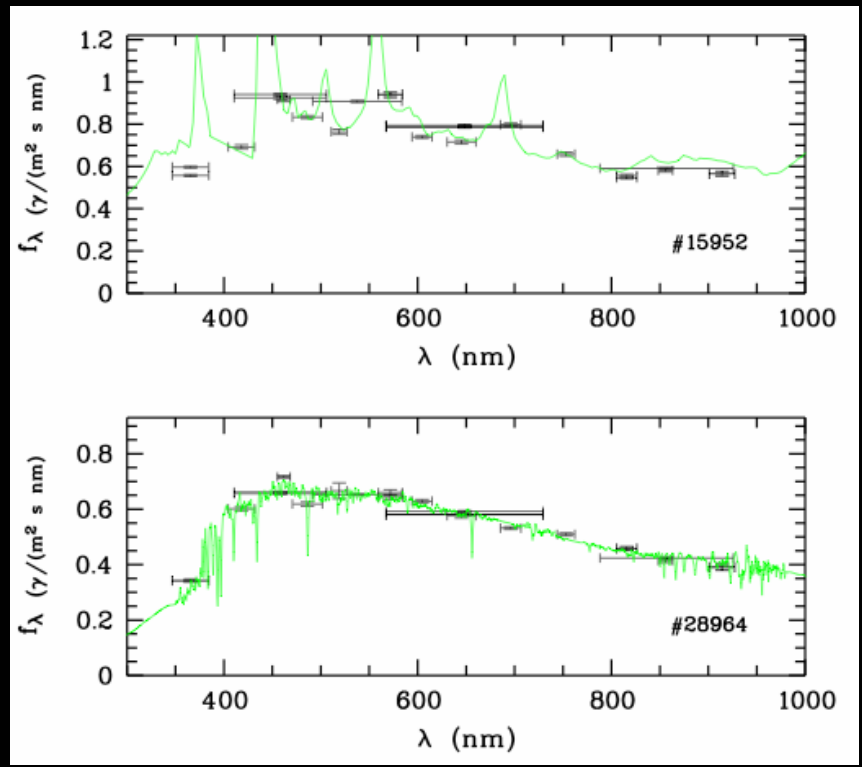
- Samples cover narrow L range
- L strongly redshift-dependent
- Bound to “see” PLE

Recent Surveys

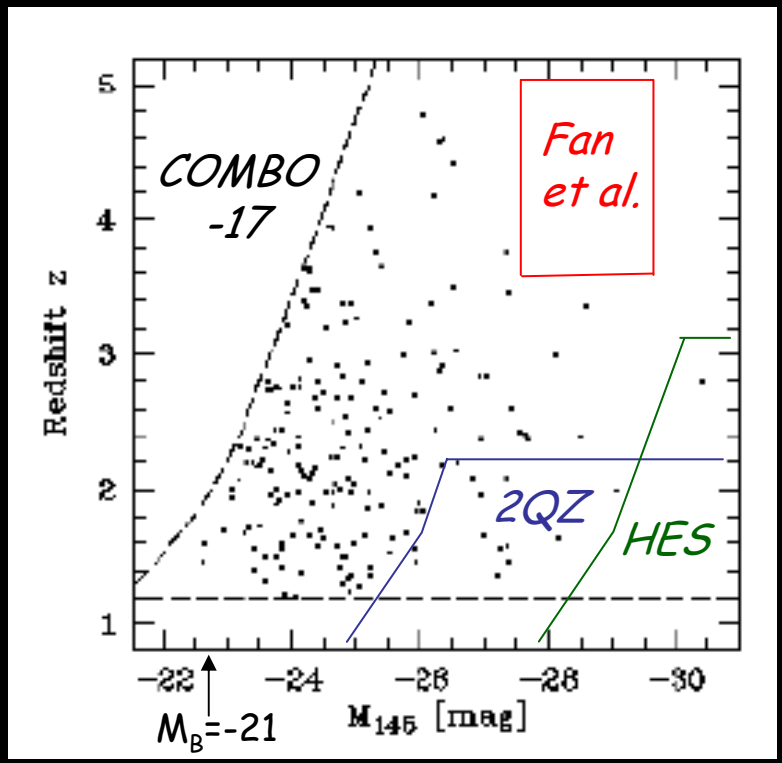
Survey	Redshift	Limit	Selection	Sample
HES	0.0…3.2	B<17	obj. prism	~400
2QZ	0.0…2.2	B<21	phot. plates	~23,000
SDSS	0.0…5.4	I<20	ugriz	~16,000
COMBO-17	0.5…6.0	R<24	17 bands	~300
BTC40	4.8…6.0	I<22	BVIz	2
Steidel et al.	~3.0	R<25.5	Ly Break	11

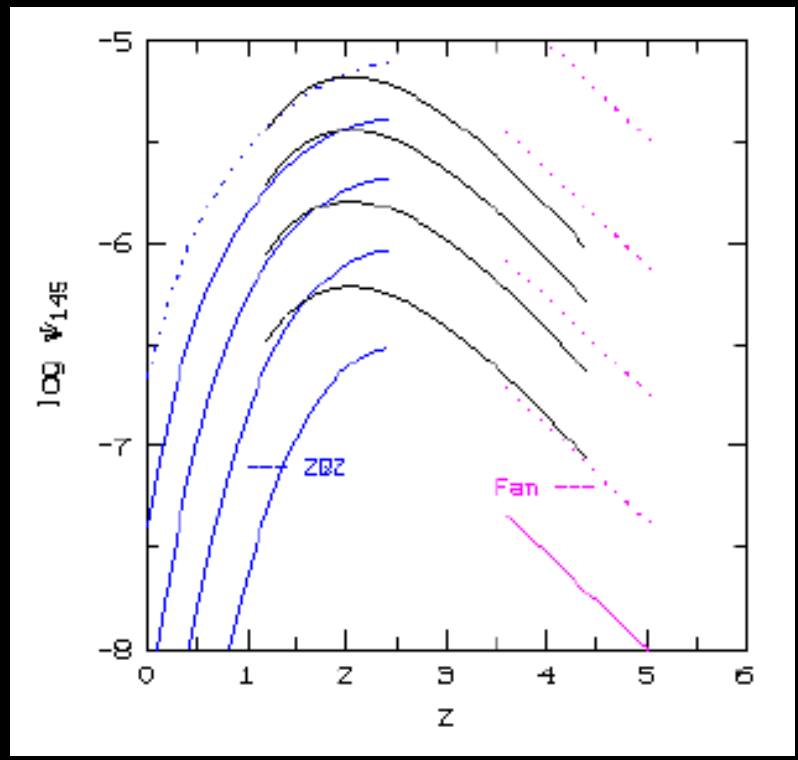
Quasar Photometric Redshifts

- SDSS ugriz
  - σ_z ~ 0.2 (templates)
    - *Richards et al. 2001*
  - σ_z ~ 0.1 (NN)
    - *Budavari et al. 2001*
- COMBO-17
  - $\sigma_z / (1+z)$ ~ 0.015 (templates)
    - *Wolf et al. 1999-2004*



Results - Evolution of Ψ

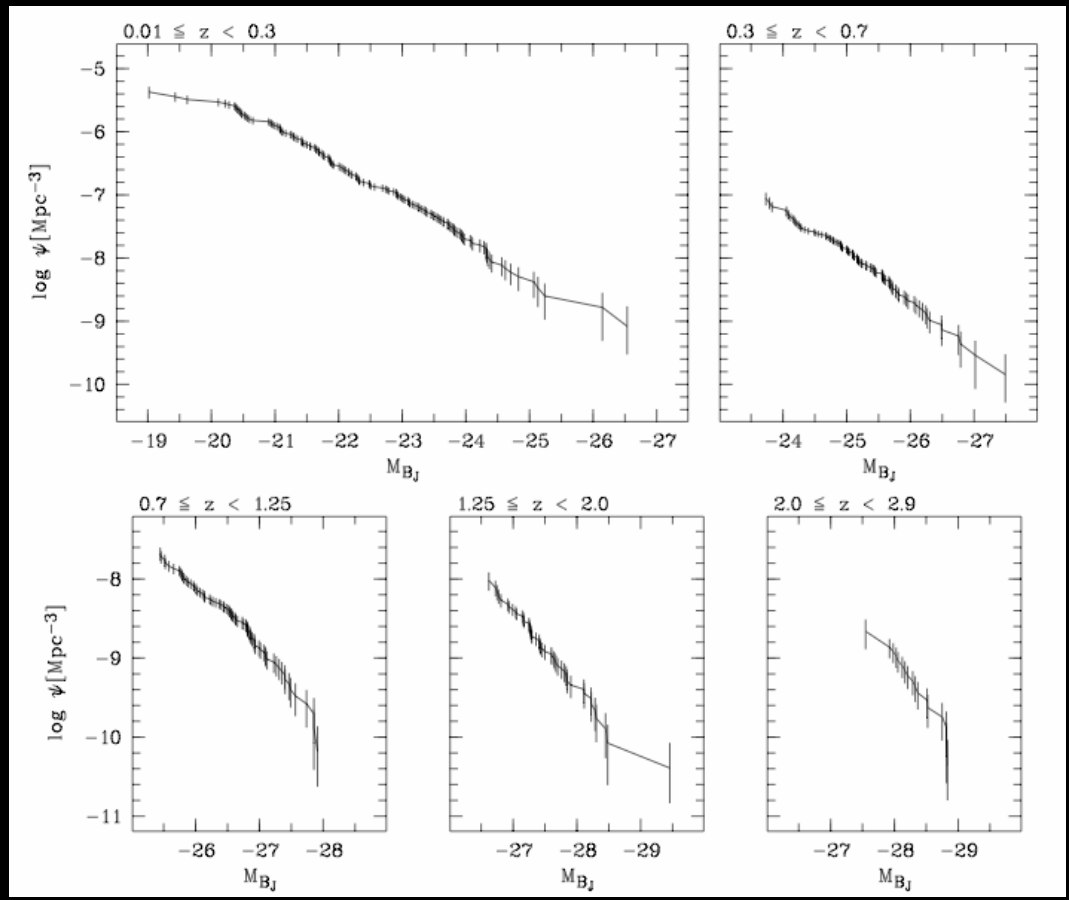




- HES *Wisotzki et al. 2000*
- 2QZ *Boyle et al. 2000, Croom et al. 2004*
- SDSS *Fan et al. 2001*
- COMBO-17 *Wolf et al. 2003*

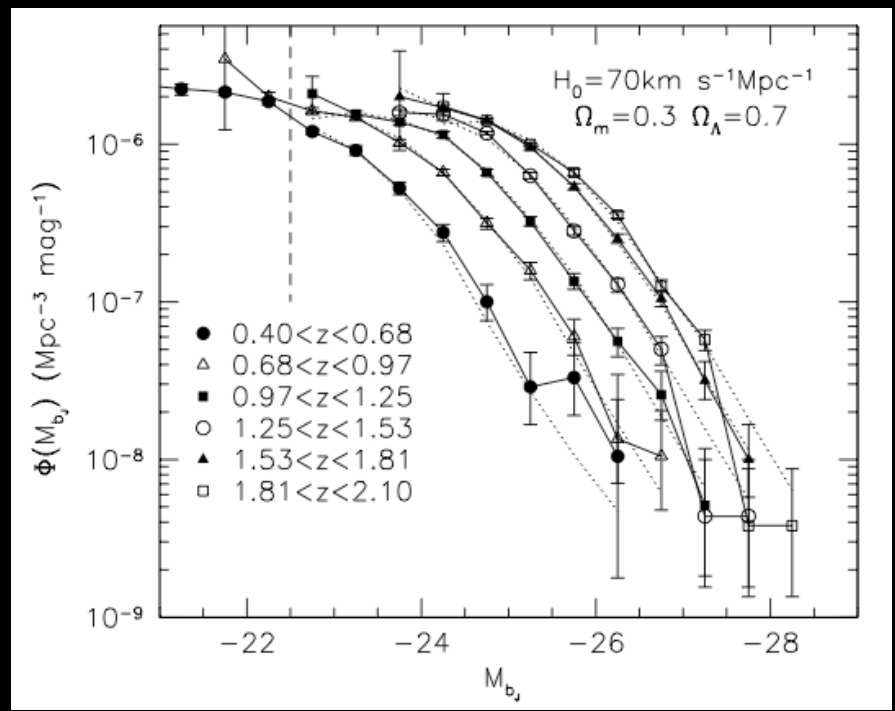
Results - LF shape 1/6

- HES
  - *Wisotzki 2000*
  - Some LF curvature
  - No L* seen at low redshift



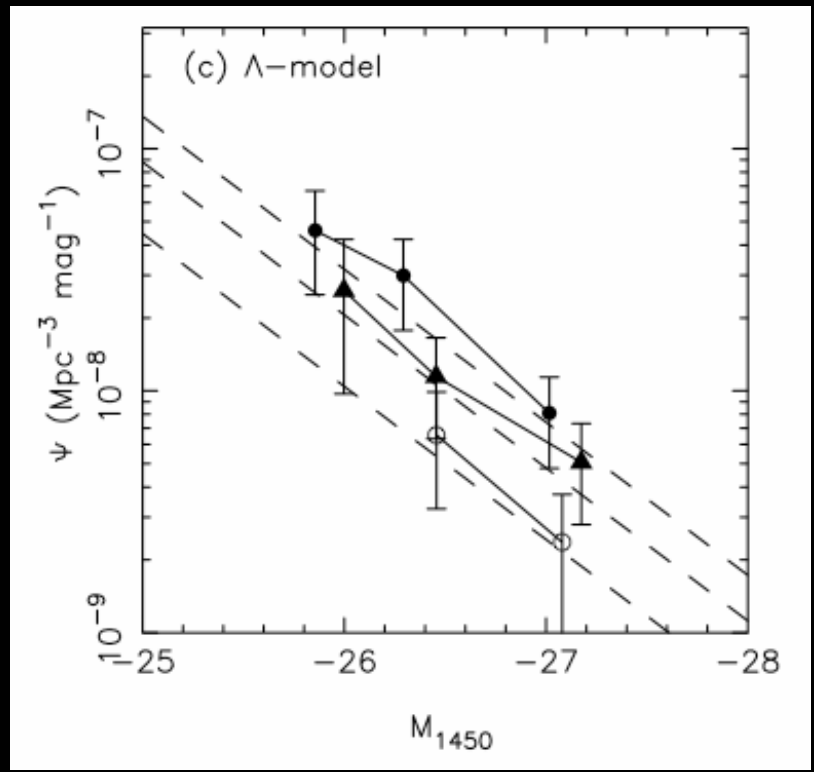
Results - LF shape 2/6

- 2QZ
  - *Boyle et al. 2000*
  - *Croom et al. 2004*
  - Broken power law
  - PLE not great fit, but satisfactory
  - $L^* \sim e^{6.15\tau}$



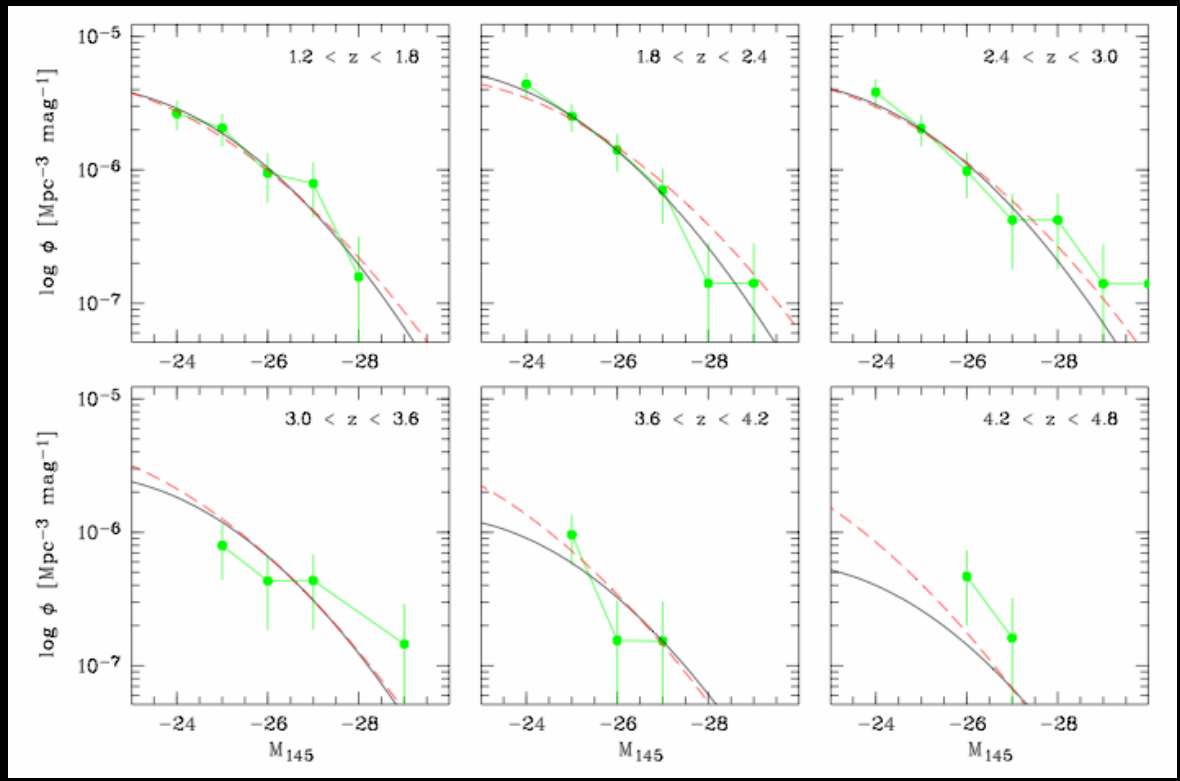
Results - LF shape 3/6

- SDSS
  - *Fan et al. 2001*
  - Linear LF due to narrow L range
  - No L* constraints
  - Slope flatter here than in 2QZ



Results - LF shape 4/6

- COMBO-17
  - *Wolf et al. 2003*
  - Some LF curvature
  - No L* seen at faint L, may be brighter

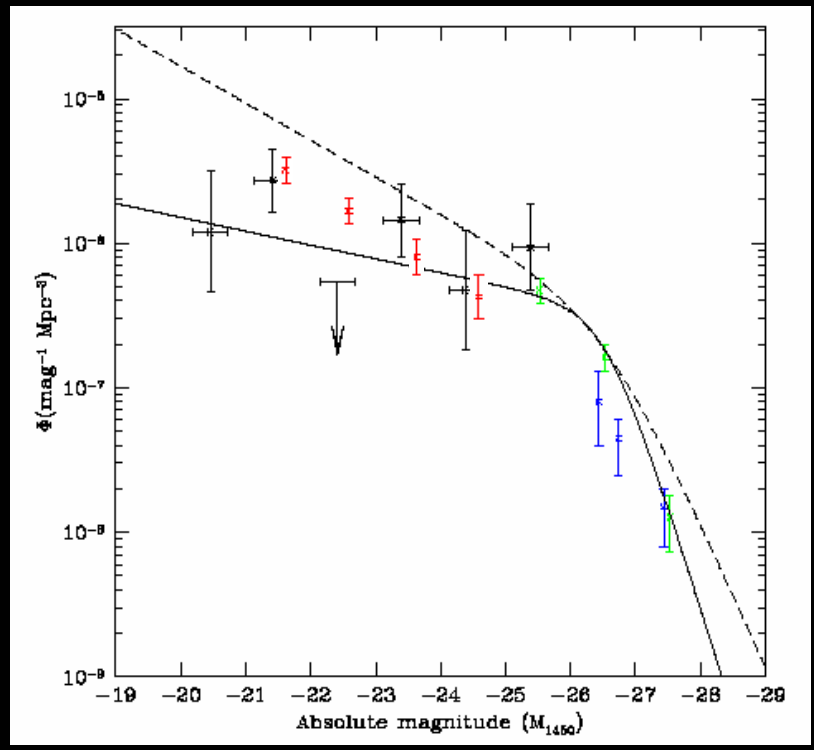


Results - LF shape 5/6

- BTC40
  - *Monier et al. 2002*
  - TWO objects

Results - LF shape 6/6

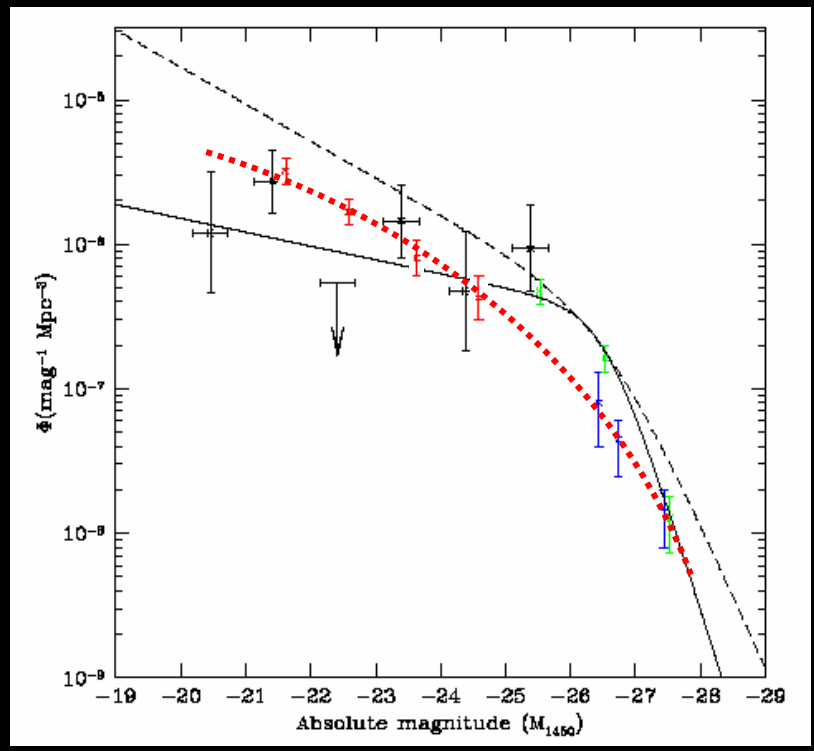
- Steidel et al.
  - *Hunt et al. 2004*
  - Flat faint end
  - *Hunt et al. + WHO94* see clear L* knee



Black: *Hunt, Steidel et al. 2004*
Blue: *Fan et al. (2001), evolved to z=3*
Green: *Warren, Hewitt & Osmer 1994*
Red: *COMBO-17 (2003)*

Results - LF shape 6/6

- Steidel et al.
  - *Hunt et al. 2004*
  - Flat faint end
- COMBO-17 + SDSS
  - No L* knee

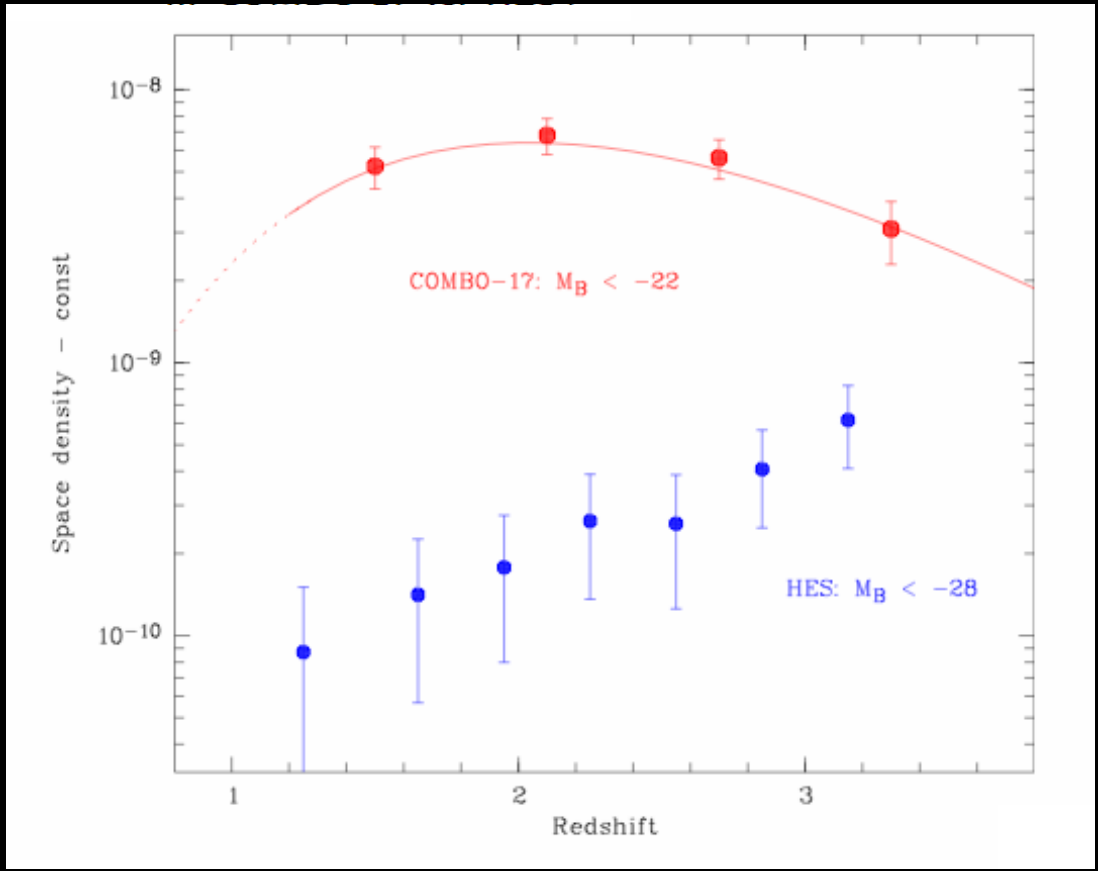


Black: *Hunt, Steidel et al. 2004*
Blue: *Fan et al. (2001), evolved to z=3*
Green: *Warren, Hewitt & Osmer 1994*
Red: *COMBO-17 (2003)*

Results - Peak Redshift z(L)

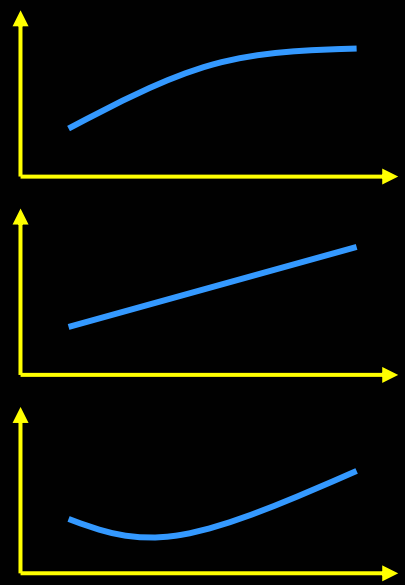
- COMBO-17
  - Faintest
- HES
  - Brightest
- See X-rays

  Cowie et al., *Steffen et al. 2003*, low-L_x peak at z~0.75



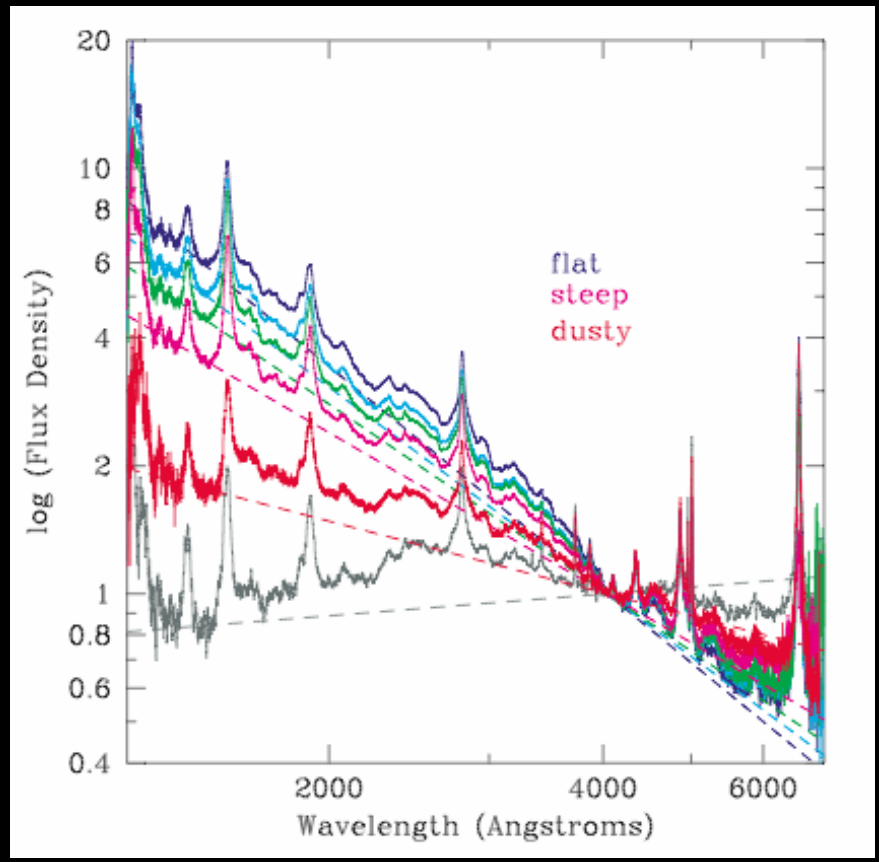
Results - Red(dened) QSOs?

- Are we missing a whole population of red quasars ???
  - Dust reddening
  - Red continuum
  - Red synchrotron component



Results - Red(dened) QSOs?

- Study continuum properties carefully
  - SDSS z = 0.0…2.2, plus 2MASS
  - Group ~5000 QSOs into six templates
  - *Richards et al. 2003, Hopkins et al. 2004*



Results - Red(dened) QSOs?

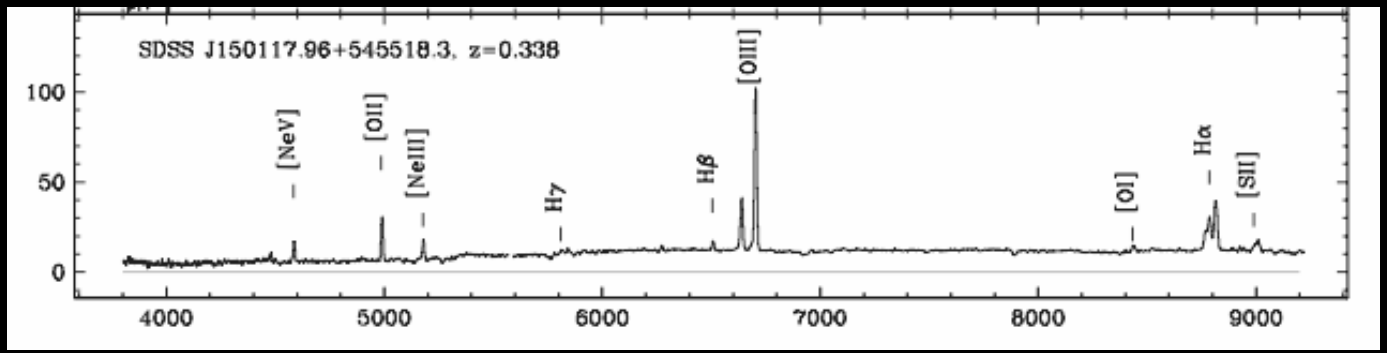
- SDSS+2MASS continuum properties
  - Intrinsic slopes α = [-0.75,-0.25]
  - Plus SMC-like dust reddening at QSO z
  - Continuum and BLR reddened (not NLR!)
  - $<E_{B-V}>$ = 0.03, sensitive to $E_{B-V} < 0.5$
  - 2% with $E_{B-V} > 0.1$
  - A total of 10% are lost from SDSS sample due to extinction (NOT reddening!)

Optically obscured AGN

- 5 Years ago
  - Low-L type-II AGN known for decades (Seyfert-2)
  - High-L type-II QSOs ??
    - Candidate at z=0.44 most powerful IRAS source *(Kleinmann et al. 1988)*
- Recently
  - X-ray evidence from BeppoSAX
    - *Franceschini et al. 2000*
  - Several QSO-II from Chandra, XMM
    - Up to z=3.7 (*Norman et al. 2002*)
    - Not the dominating population at high L

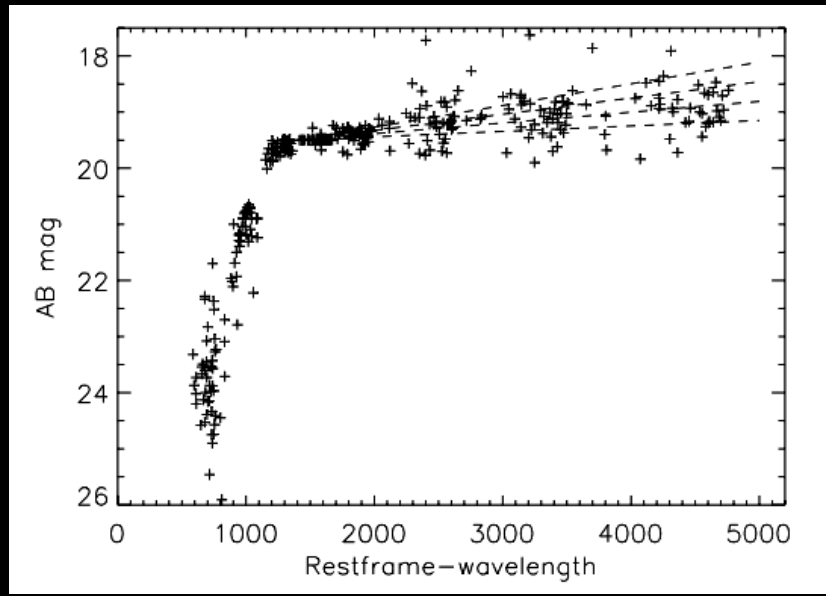
Optically obscured AGN

- *Zakamska et al. 2003, 2004*
  - Serendipitous sample from SDSS spectroscopy
  - z=0.3…0.8
  - 150 QSO-II with $L_{OIII} > 3 \times 10^8 L_{sol}$
  - Optical+NIR: host galaxy continuum + NLR
  - MIR/FIR- luminous and hard X-ray colours



Spectral Index Evolution?

- *Pentericci et al. 2003*
  - 45 QSOs, z=3.6…5
  - SDSS data + JHK photometry
  - α = -0.57 ± 0.33
  - NO EVOLUTION compared to z~1



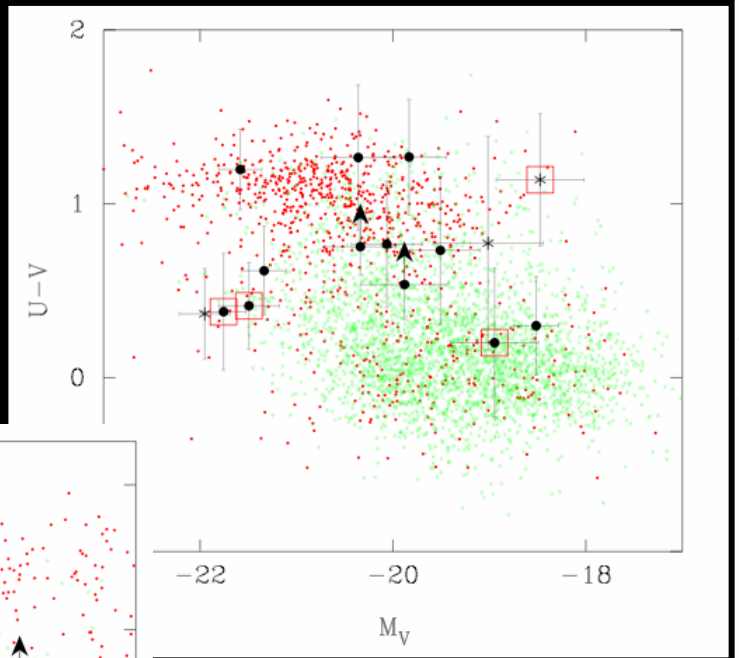
Evolution of Emission Lines?

- *Croom et al. 2002, Dietrich et al. 2002*
  - Various Baldwin effects = (anti-) correlation of line-EW and L
  - NO EVOLUTION of line-EW's with redshift
- *Corbett et al. 2003*
  - If BLR in Keplerian orbits and $r_{BLR} \sim L_{QSO}^{0.7}$
  - Then $M_{BH} \sim L_{QSO}$, and NO EVOLUTION

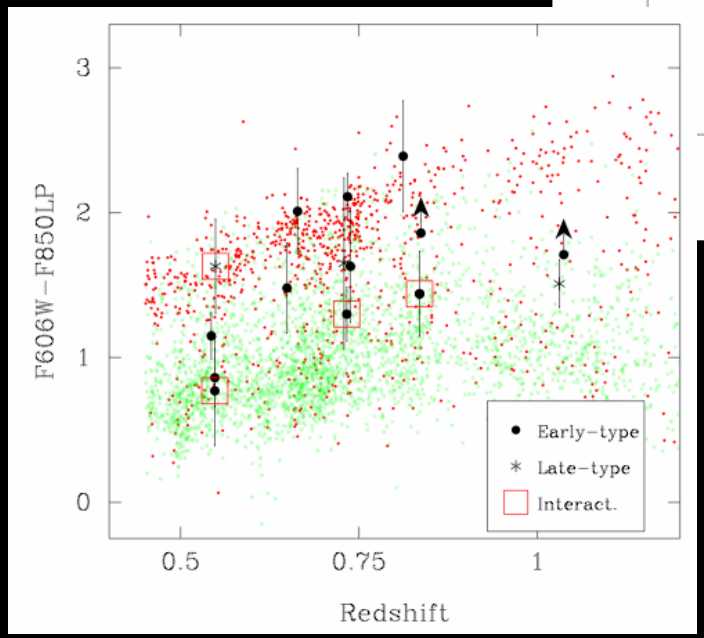
AGN Host Galaxies

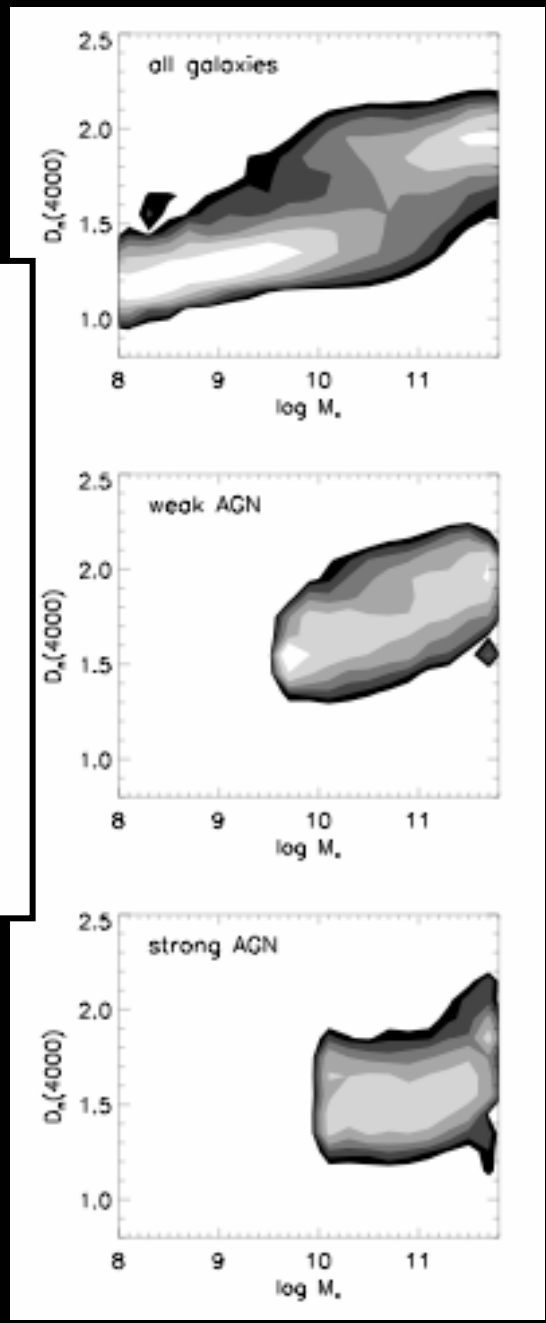
- *Dunlop et al. 2003* z<0.2 M_V<-23.5
  Kukula et al. 2001 z=0.9…1.9 M_V=-25...24
  - Normal giant E galaxies, Kormendy relation normal
- *Kauffmann et al. 2003* z<0.3 type-II
  - Normal early-type galaxies
  - Low-L: normal red colour
  - Medium-L: excess of blue star light w.r.t. non-AGN
- *Jahnke et al. 2004* *z<0.2* M_V=-24…-21
  Sanchez et al. 2004 z=0.5…1.1 M_V=-24…-20
  - Normal early-types + some disks
  - Early-types: excess of blue star light w.r.t. non-AGN, but not strong starburst

Host Galaxy Colours



Sanchez et al. 2004





Kauffmann et al. 2003

Current Challenges

- Observations
  - Map QSO L-z plane completely (optical and X-ray)
  - Push type-II surveys to higher redshift
- Analysis
  - z_{max} (L), changing shape of QSO-LF
  - Evolution in obscuration?
  - Measure accretion rates - if low, why? (ε, M, dM/dt)
- Interpretation
  - Relating observed to physical evolution
  - Self-consistent, accretion & BH mass function

Summary

- QSO-LF: No simple model and parameterization
- Cosmic Downsizing: low-L peaks at low-z, hi-L at hi-z
- Type-I population completely observed
- No spectral evolution
- Type-II catching up, still work to do (high-z!)
- Type-II fraction high at low-L, low at high-L
- Host galaxies mostly large E’s (+ extra young stars)
- Interpretation of physical evolution still challenging