The Luminosity Function of High Redshift QSOs

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The High-z QSO Luminosity Function

(Fontanot, Cristiani and the GOODS Team , 2006)

Motivations

- Quasars are luminous but rare sources
  - Large area surveys vs Deep survey
  - Bright end vs Faint end
- Faint end of Luminosity Function
  - Measure QSO contribution to the UV background (Madau et al., 1999)
  - Constraints on the mechanisms responsible of the joint formation of supermassive black holes and host galaxies

GOODS Project

- Study Galaxy Formation and Evolution over a wide range of cosmic lookback times (Giavalisco et al., 2004)

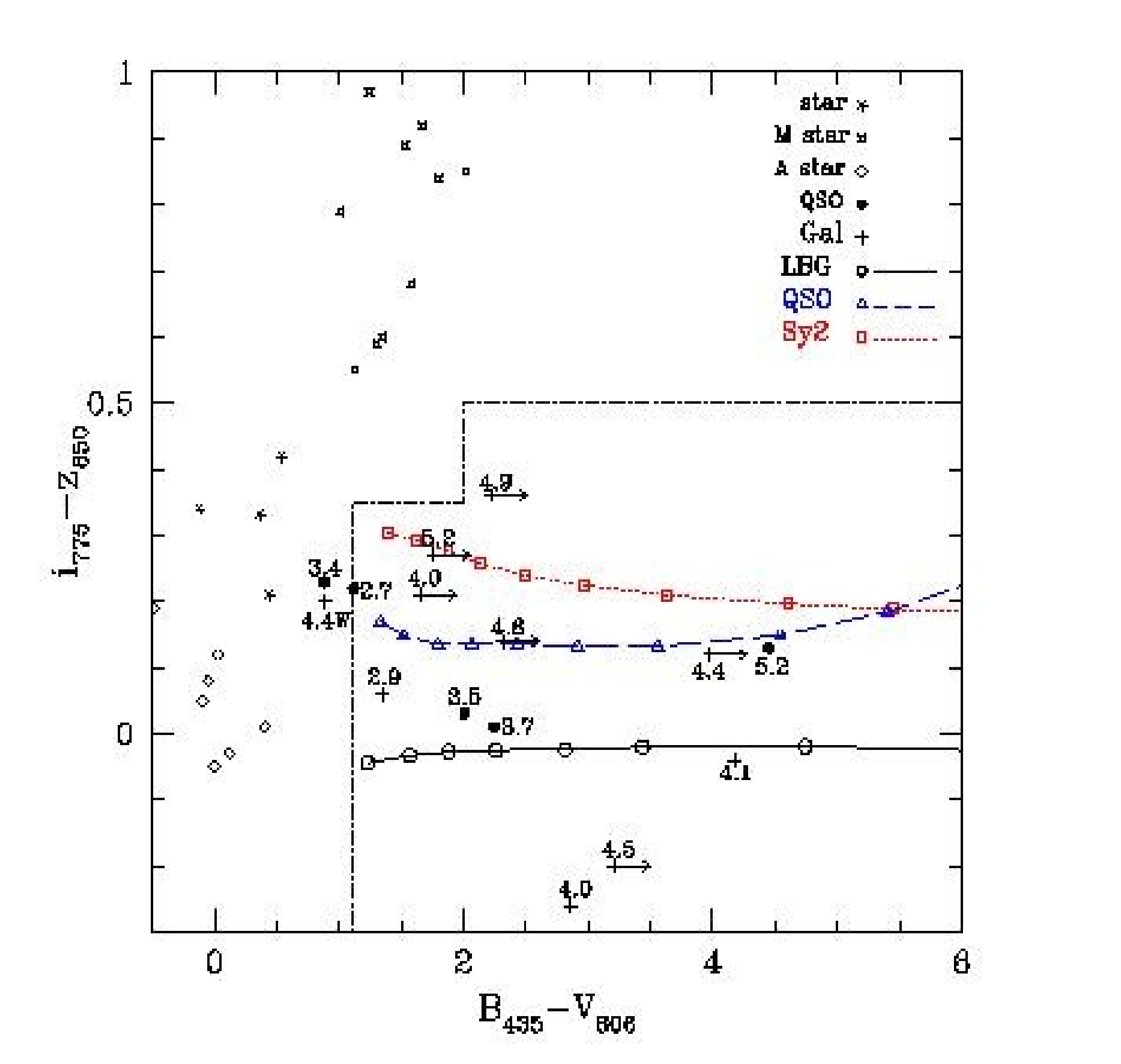
- Multiwavelenght survey

  - Two fields centered on HDFN and CDFS

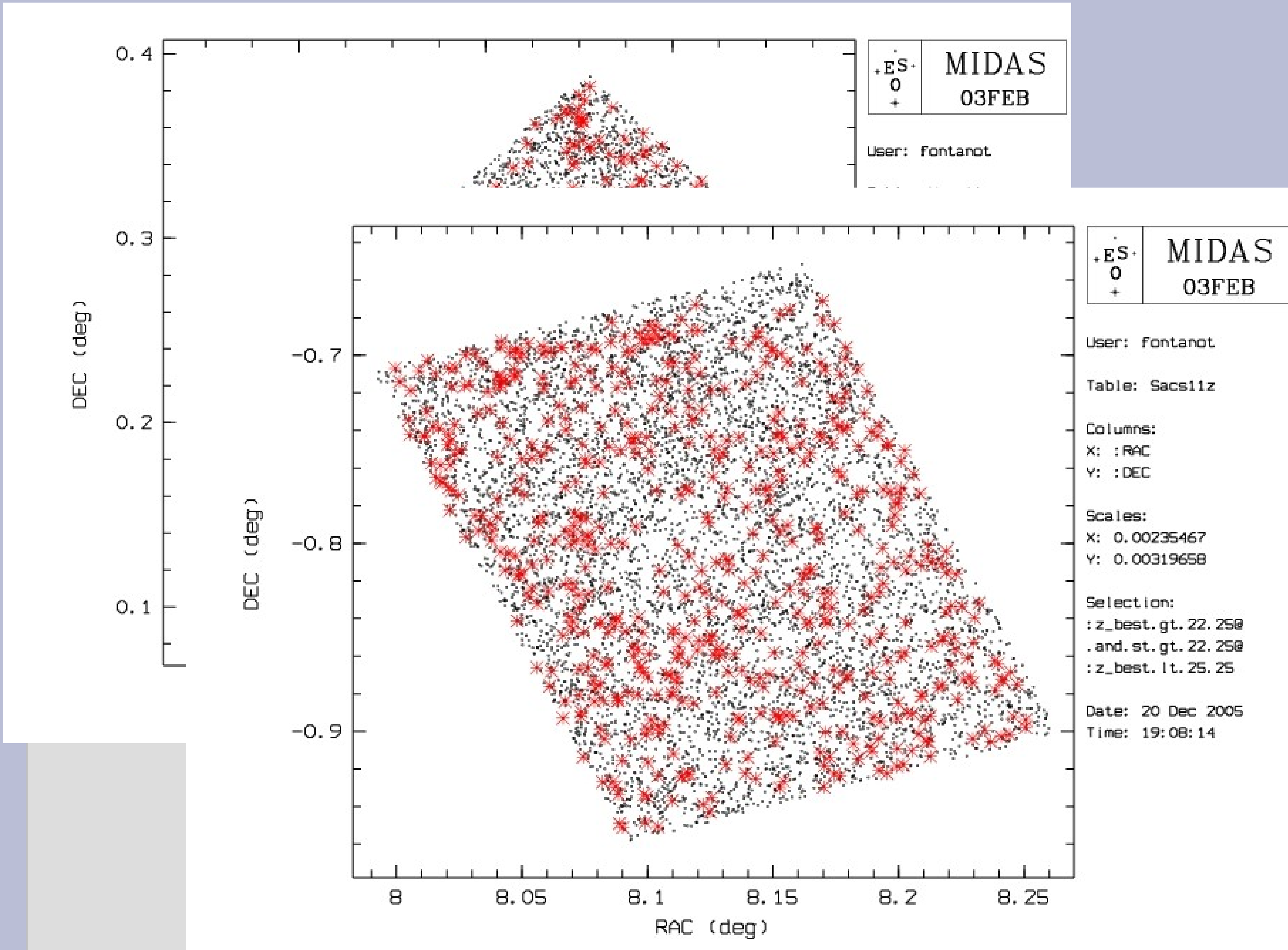
Selection of optical candidates

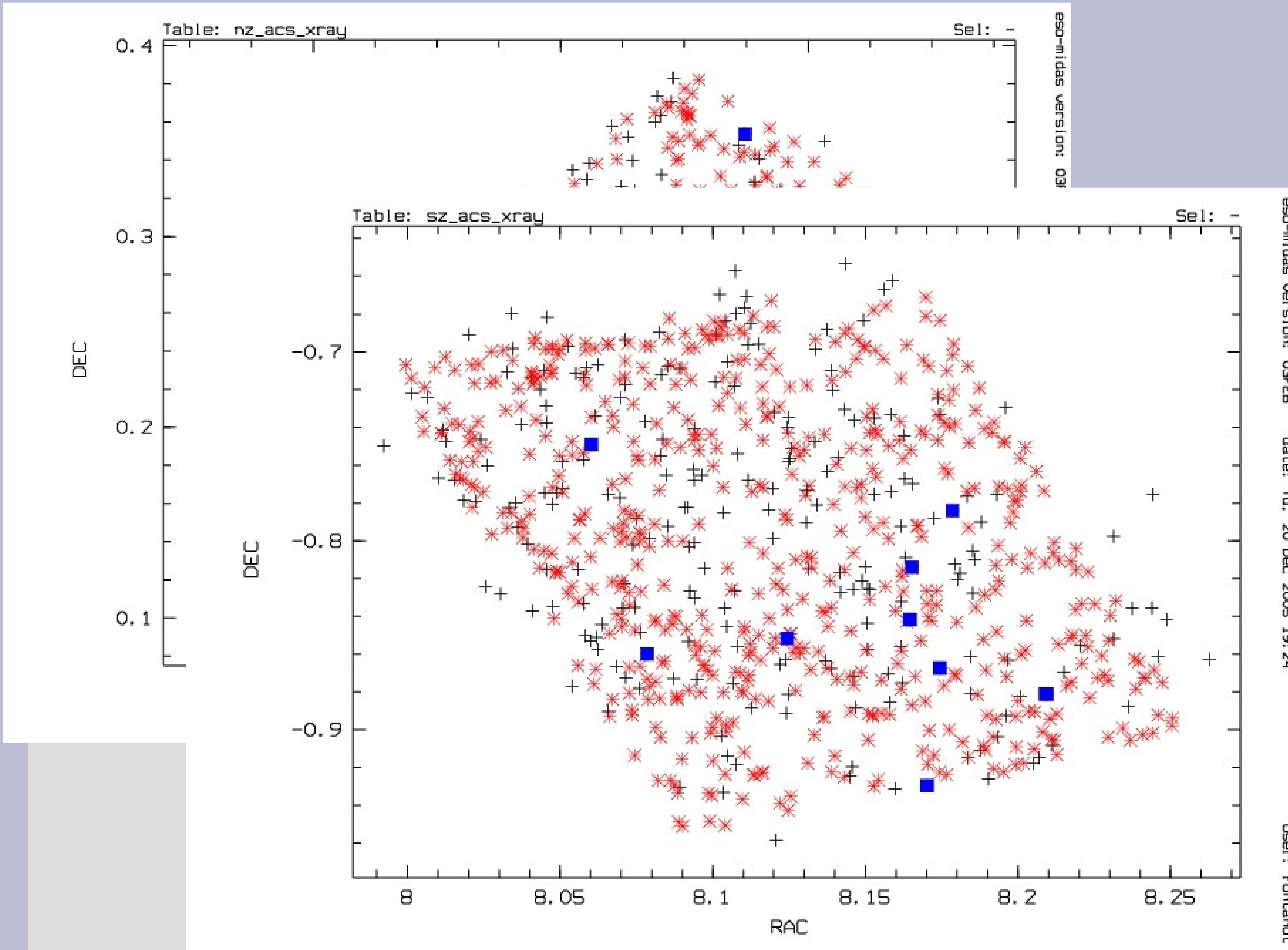
- Optical data from ACS (B_{435}, V_{606}, i_{775}, z_{850})
- Selection Criteria (Cristiani et al., 2004)
  - Magnitude Limit $22.45 < z_{850} < 25.25$
  - Color Criteria tested on template spectra (Cristiani & Vio, 1990)
    - $(i-z<0.35)\cap(V-i<1.00)\cap(1.00<B-V<3.00)$
    - $(i-z<0.35)\cap(B-V>3.00)$
    - $(i-z<0.50)\cap(V-i>0.80)\cap(B-V>2.00)$

Selection of optical candidates



- Quasar selected with 3.5<z<5.2
- Also included Ly-break and Seyfert Galaxies


MIDAS
03FEB
User: fontanot
DEC (deg)
0.4
0.3
0.2
0.1
MIDAS
03FEB
User: fontanot
Table: Sacs11z
Columns:
X: :RAC
Y: :DEC
Scales:
X: 0.00235467
Y: 0.00319658
Selection:
:z_best.gt.22.25@
.and.st.gt.22.25@
:z_best.lt.25.25
Date: 20 Dec 2005
Time: 19:08:14
DEC (deg)
-0.7
-0.8
-0.9
8
8.05
8.1
8.15
8.2
8.25
RAC (deg)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DEC
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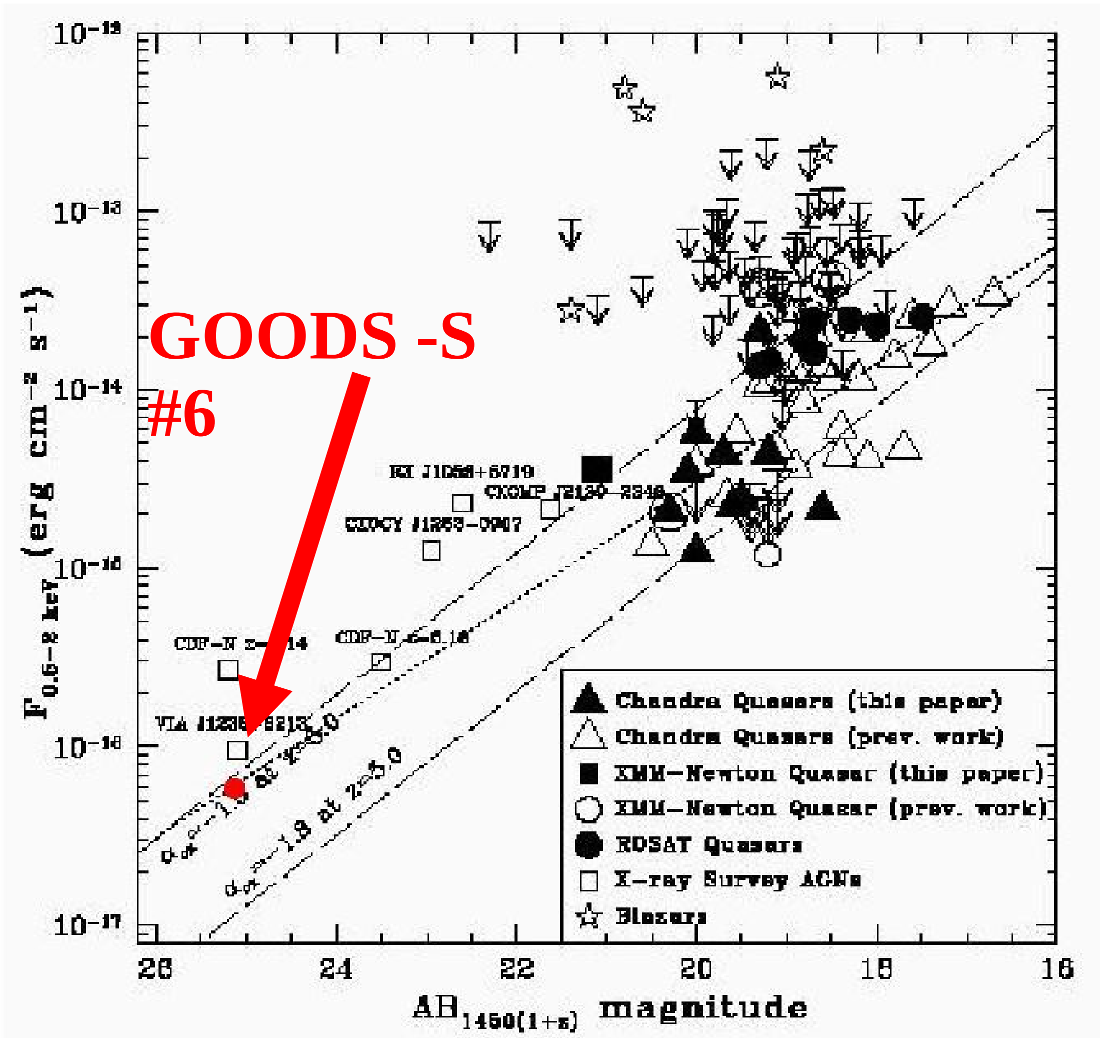
-0.8
-0.9
8
8.05
8.1
8.15
8.2
8.25
RAC
eso-midas version: 03FEB
date: Tu, 20 Dec 2005 19:24
User: fontanot

Matching with X-ray observations

- 1202 optically selected candidates
  - 557 in HDFN + 645 in CDFS
- Match with Chandra surveys
  - Alexander et al., 2003
  - Giacconi et al., 2002

X-ray Matching



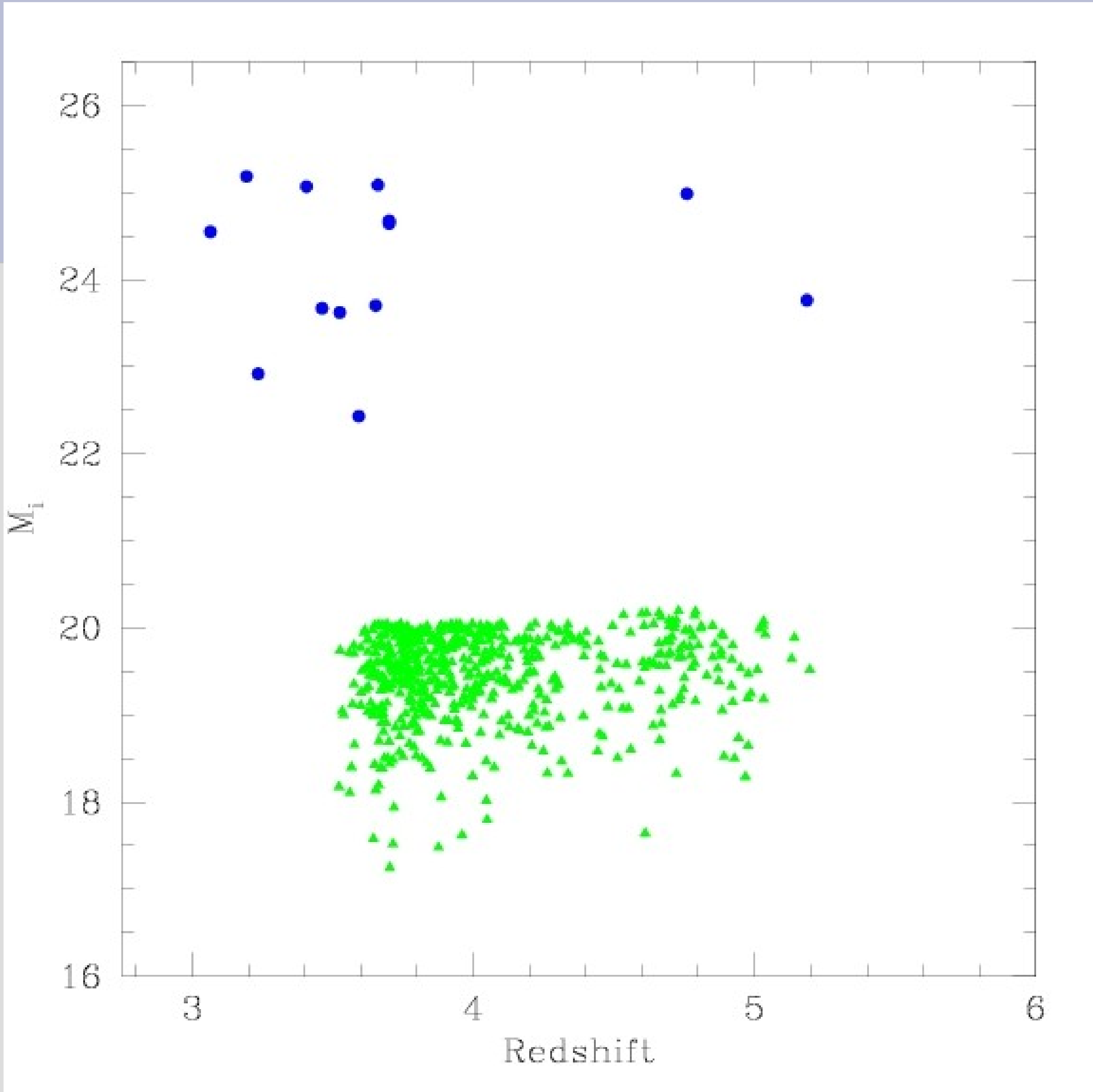
- Estimate of Visibility (Vignali et al. 2003)
  - Any $z > 3.5$ x-ray source must harbour an AGN
  - Type I QSOs with $M_{145} < -21$ up to $z \sim 5.2$

Spectroscopic Follow-up

- 50 LBGs out of optically selected candidates
- Results: QSO candidates (Vanzella et al., 2004)
  - 3 low-z galaxies
  - 12 QSOs with $2.6 < z < 5.2$
  - 2 QSOs with $z > 4$
    - QSO at $z = 5.186$ (Barger et al. 2001)
    - QSO at $z = 4.76$ (Vanzella et al. 2004)

High-z LF

- Faint QSOs
  - GOODS observations (Cristiani et al., 2004)
- Bright QSOs
  - SDSS Quasar Data Release 3 (DR3QSO: Schneider et al. 2005)
- Key Issues
  - Understanding systematics, selection effects and completeness
- Reproducing survey features

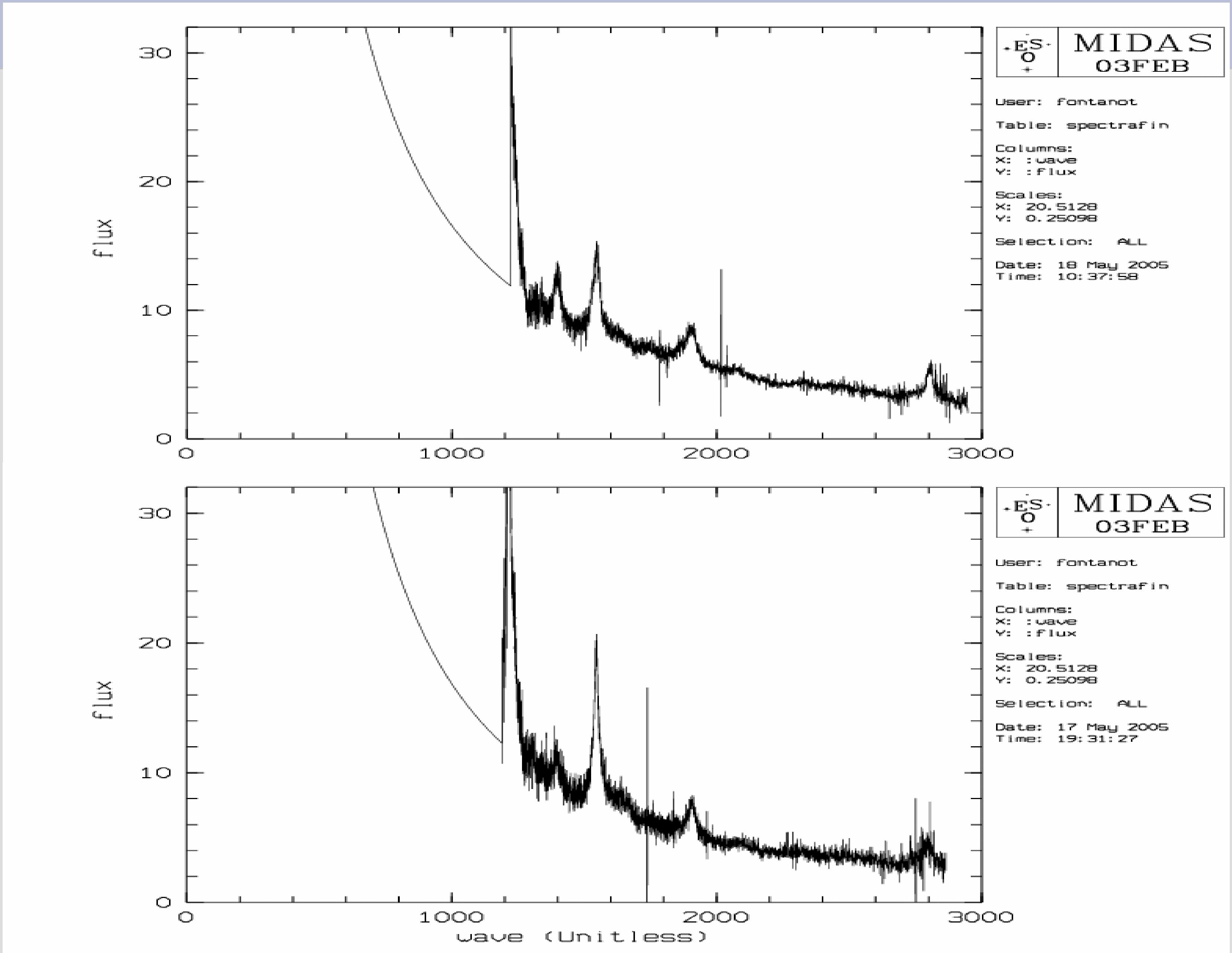


26
24
22
20
18
16
M_i
3
4
5
6
Redshift

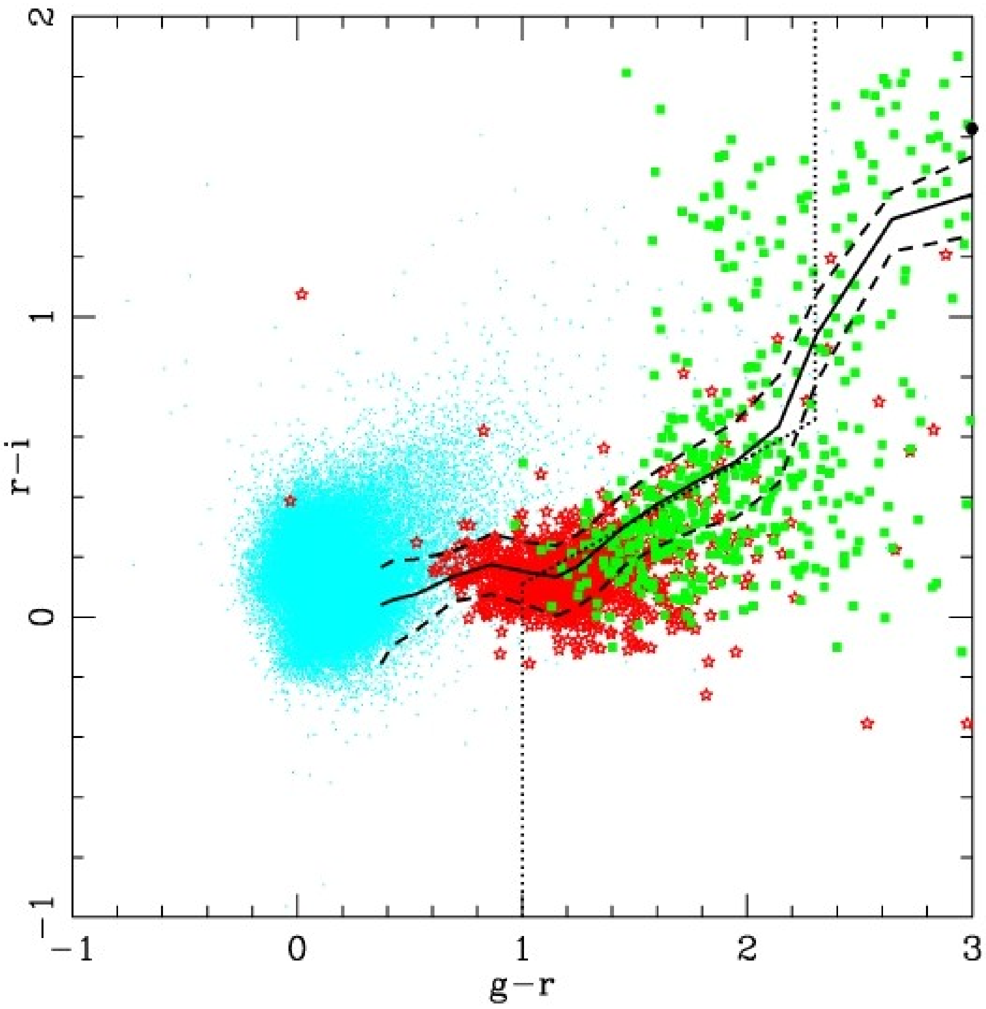
Predicting QSO color evolution

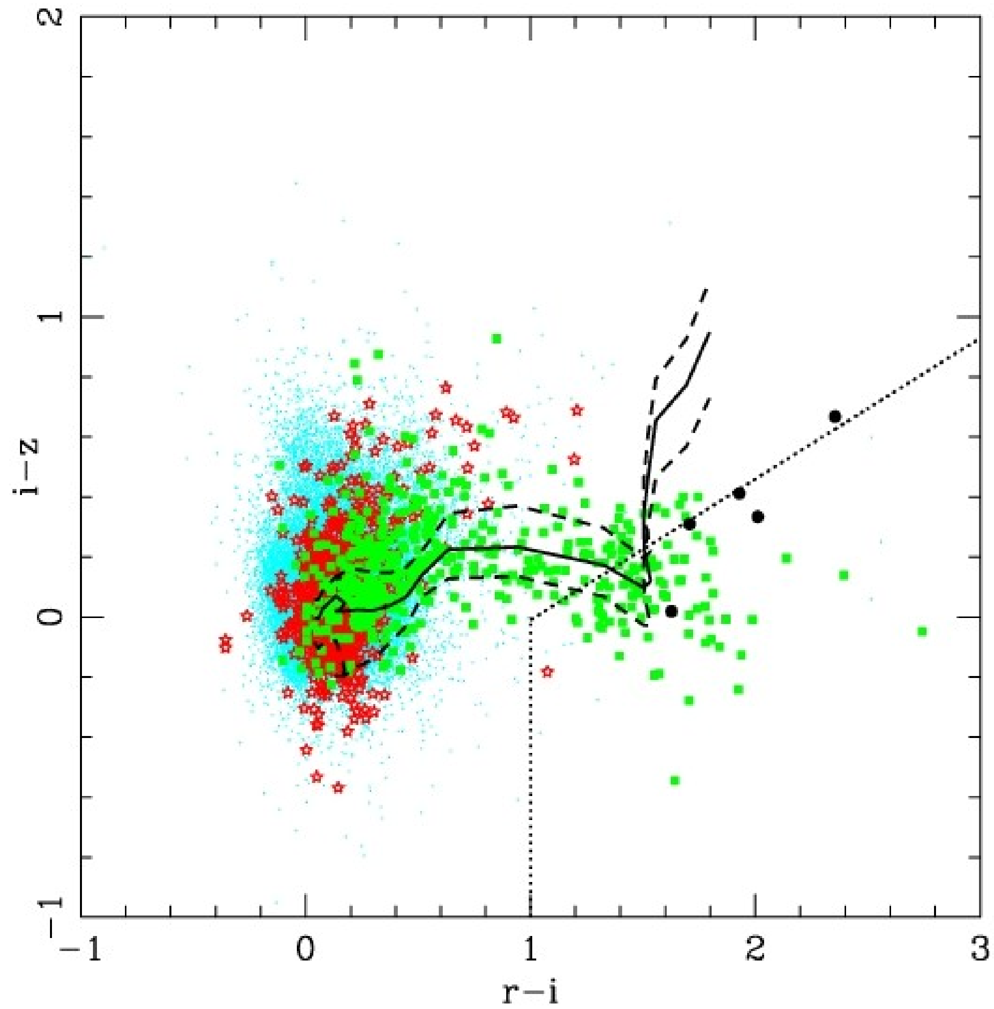
- Define a Statistical Sample of QSOs
  - High completeness redshift interval
    - $2.2 < z < 2.25$
  - High quality QSO spectra from SDSS
- Sample of 215 QSOs
- Building up template library
  - Computing restframe spectra
  - Fitting continuum
- Simulating high redshift objects
- Computing Statistical Properties

Choosing Redshift Interval

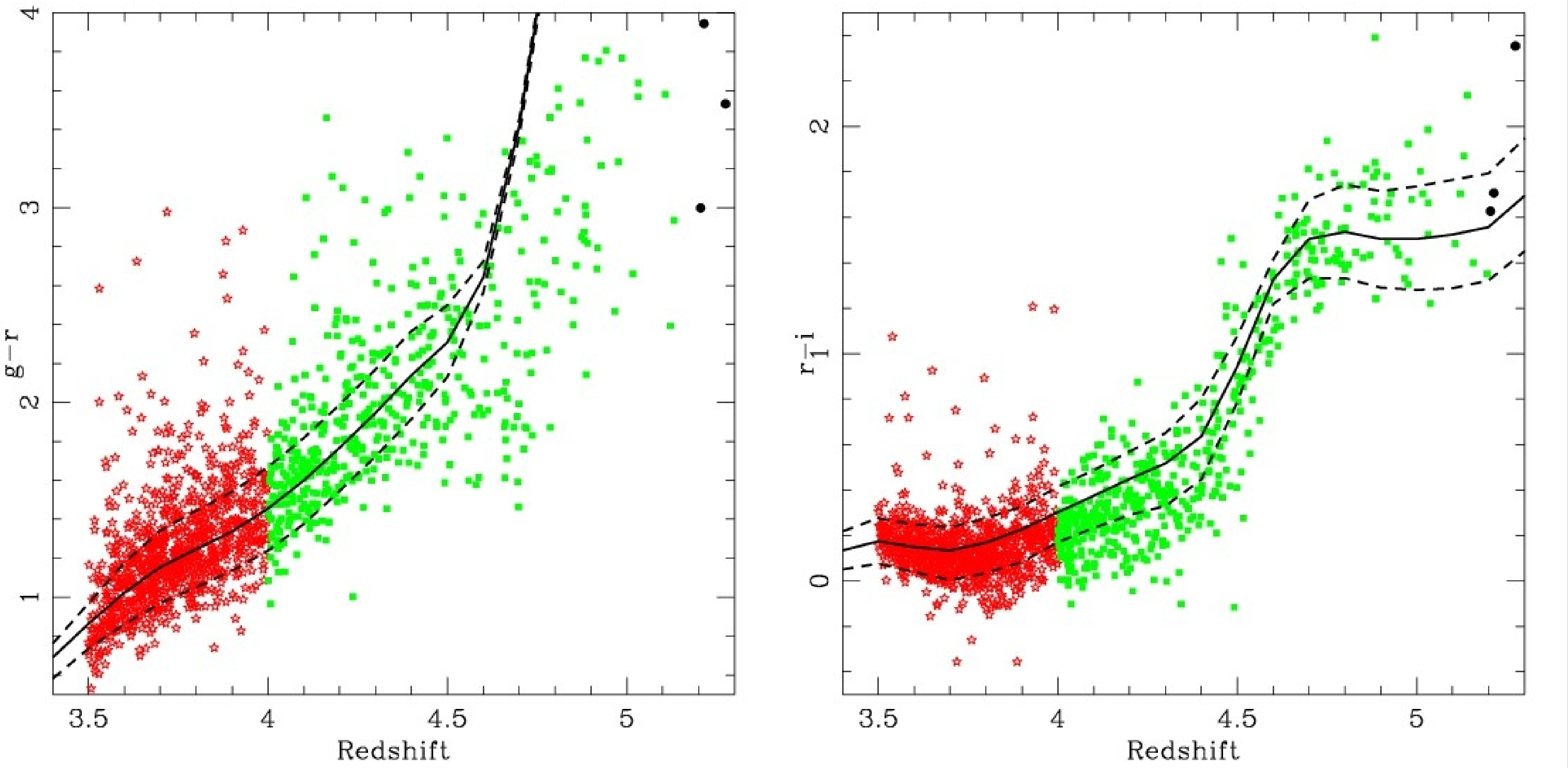


Results: Color Diagrams





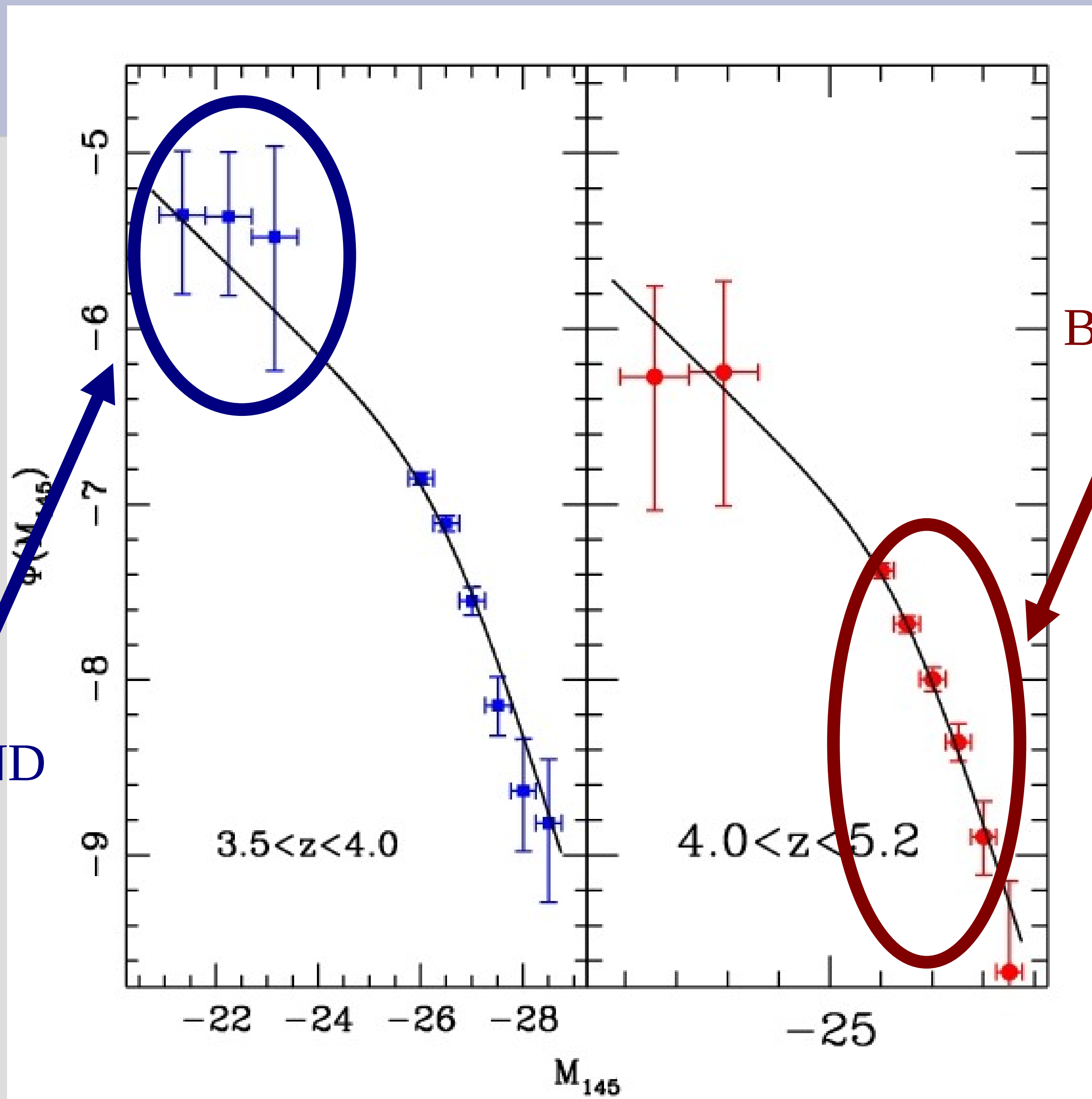
Results: Color Evolution



Computing LFs

- Analytical form for LF
  - Compute expected number of QSOs
- Simulate magnitudes in photometric systems
  - Mock SDSS and GOODS catalogues
- Apply selection criteria
  - Mock SDSS and GOODS selected catalogues
- Compare observed and simulated objects
  - Define chi square estimator
  - Evaluate agreement between data and LF

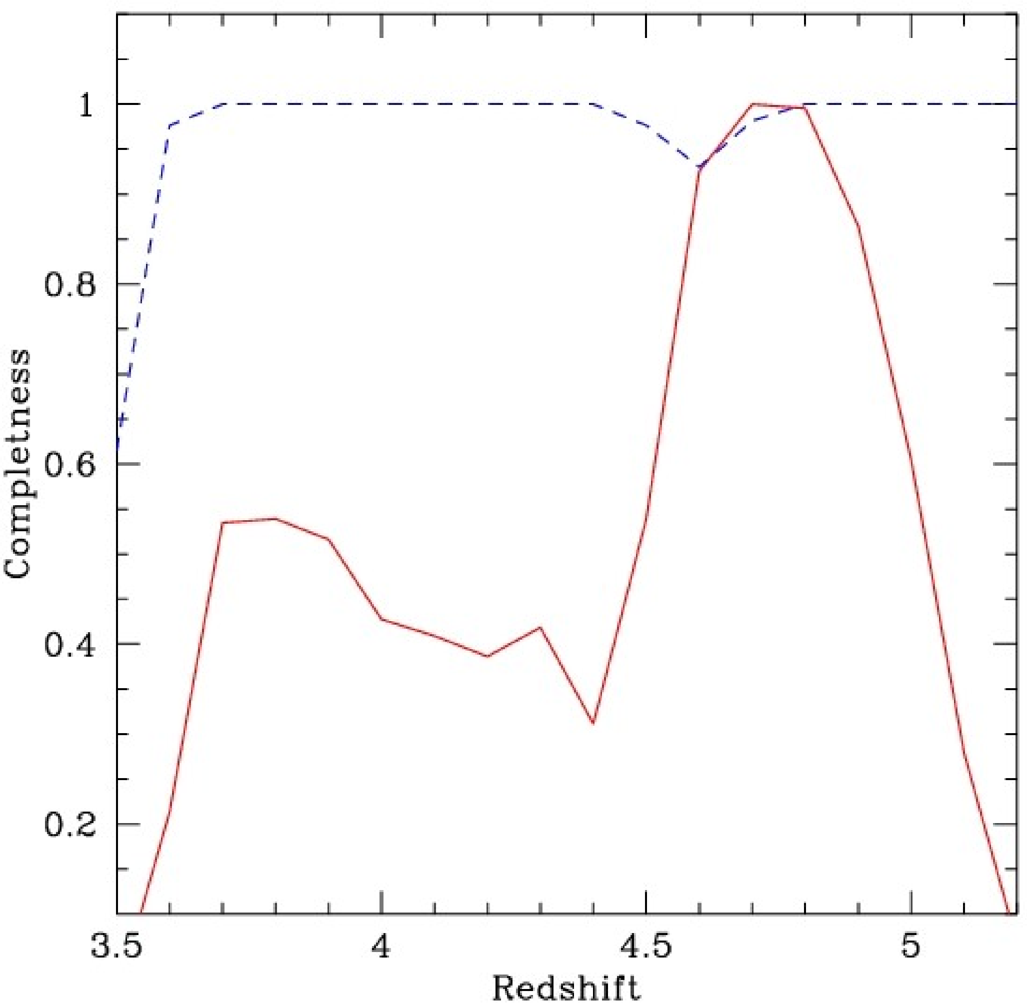
Results: LFs

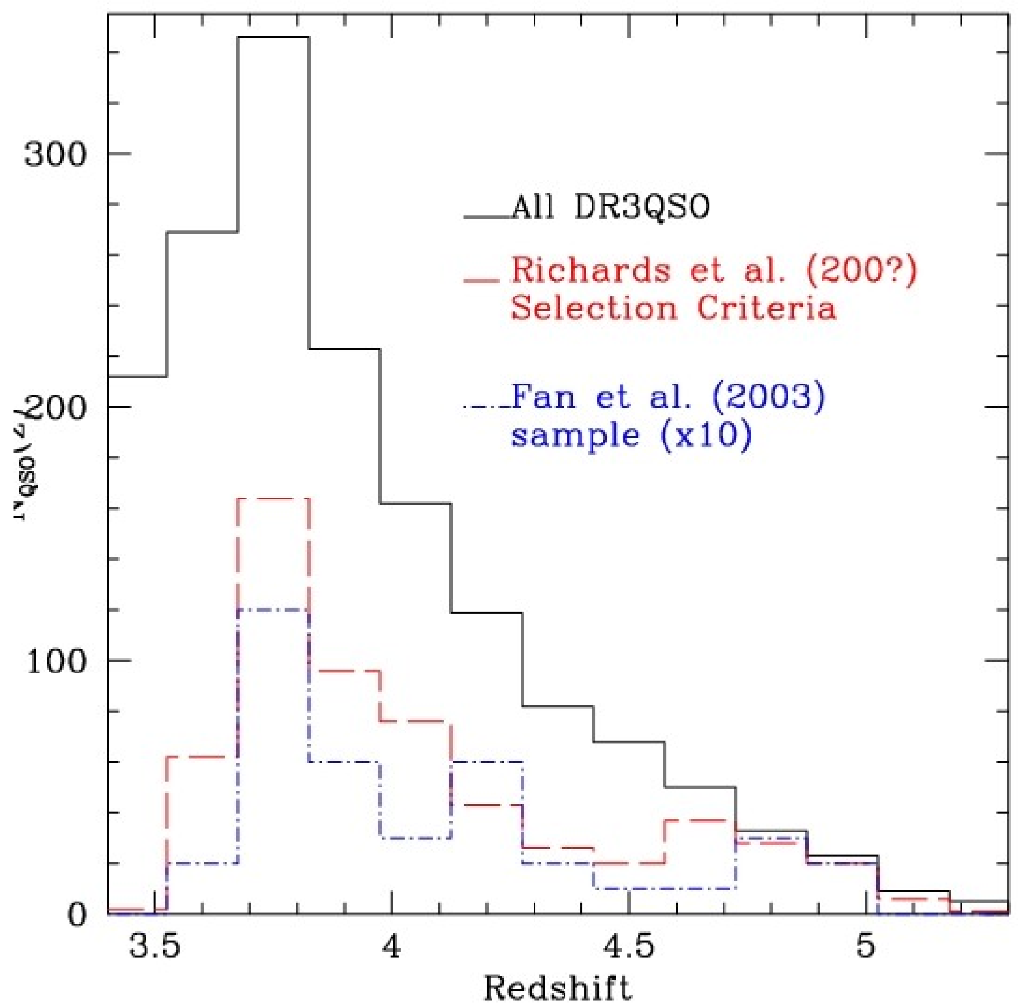


FAINT END

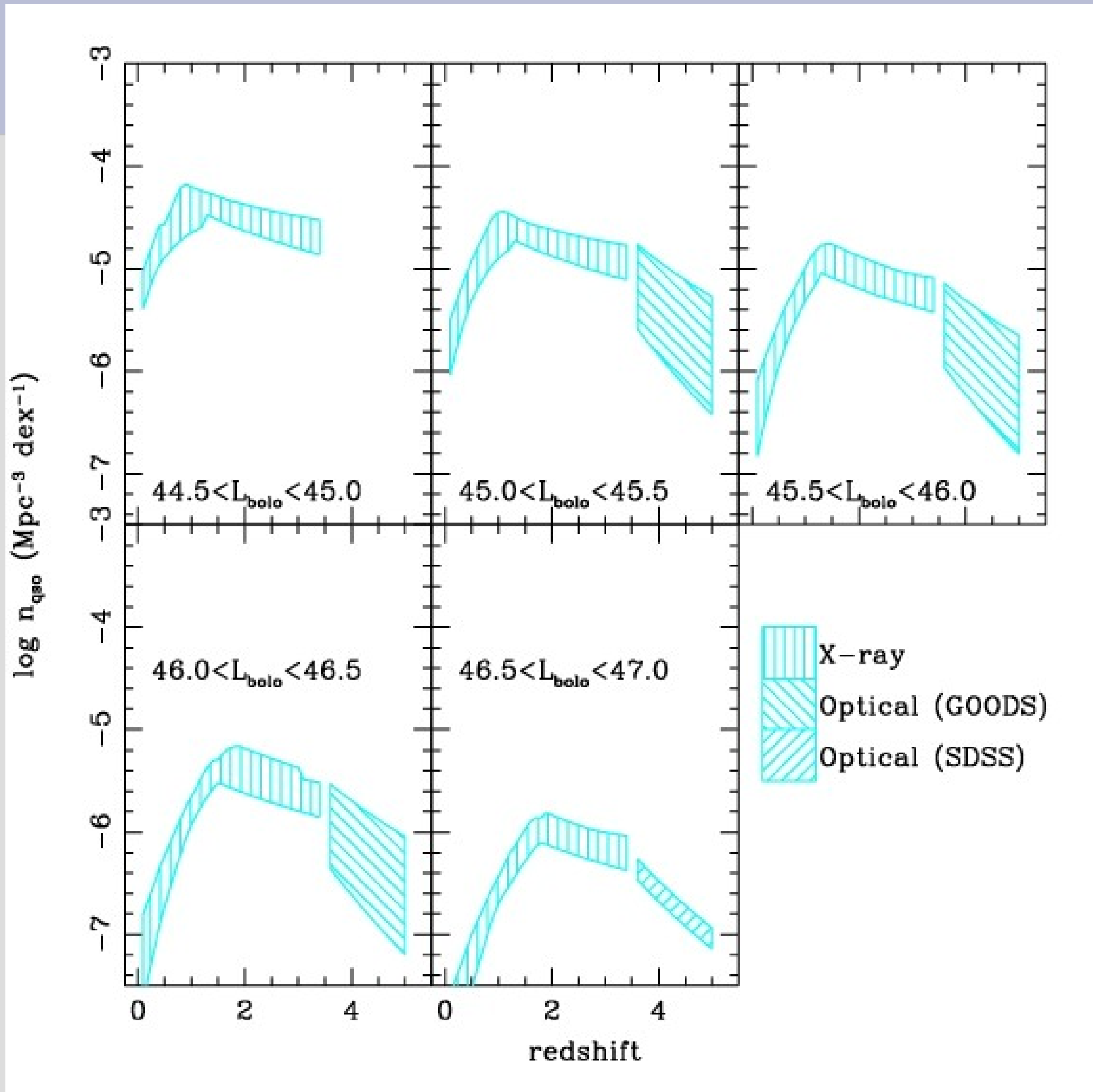
BRIGHT END

Completeness





Results



log n_{qso} (Mpc^{-3} dex^{-1})
44.5<L_{bolo}<45.0
45.0<L_{bolo}<45.5
45.5<L_{bolo}<46.0
46.0<L_{bolo}<46.5
46.5<L_{bolo}<47.0
X−ray
Optical (GOODS)
Optical (SDSS)
redshift

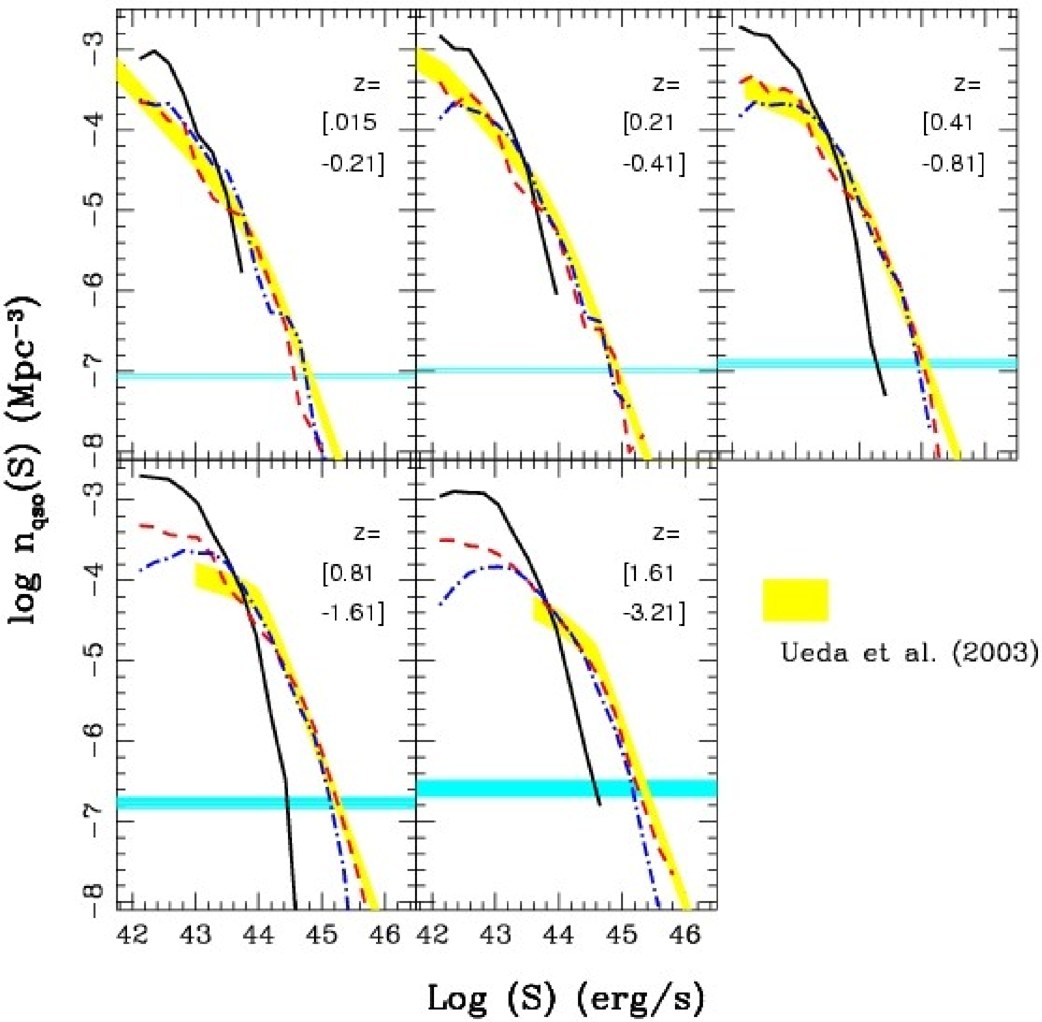
Part 1 Conclusions

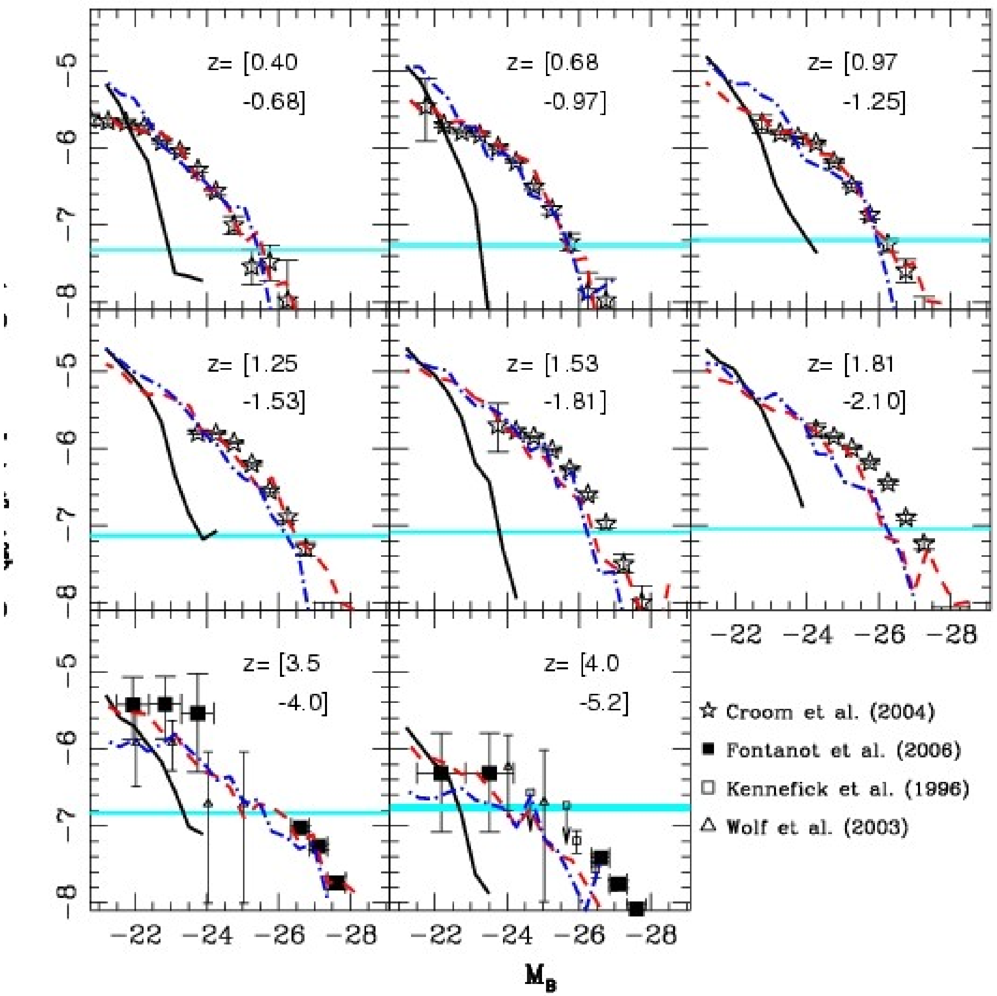
- Evolutionary models based on low-z observations
  - Pure Density evolution models provide a good fit
  - Pure Luminosity Evolution models provide a poor fit
- Faint end slope steeper than low-z observations
- Bright end slope steeper than Richards et al., 2006
- The QSO contribution to the UV background is insufficient to ionize the IGM at those redshifts

The effect of stellar feedback and quasar winds on the AGN population

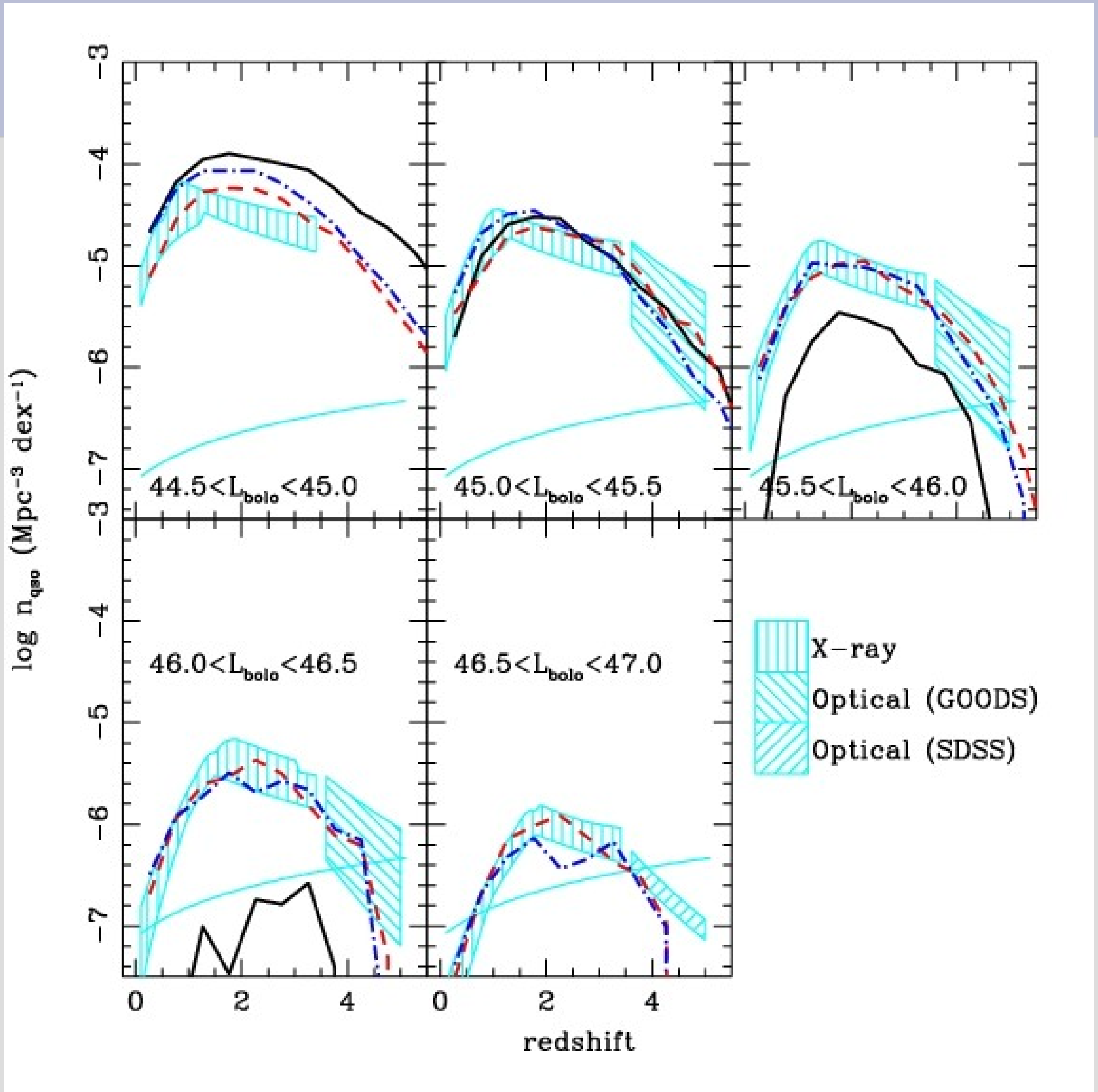
(Fontanot, Monaco et al., 2006b)

Hard X-ray and Optical LF

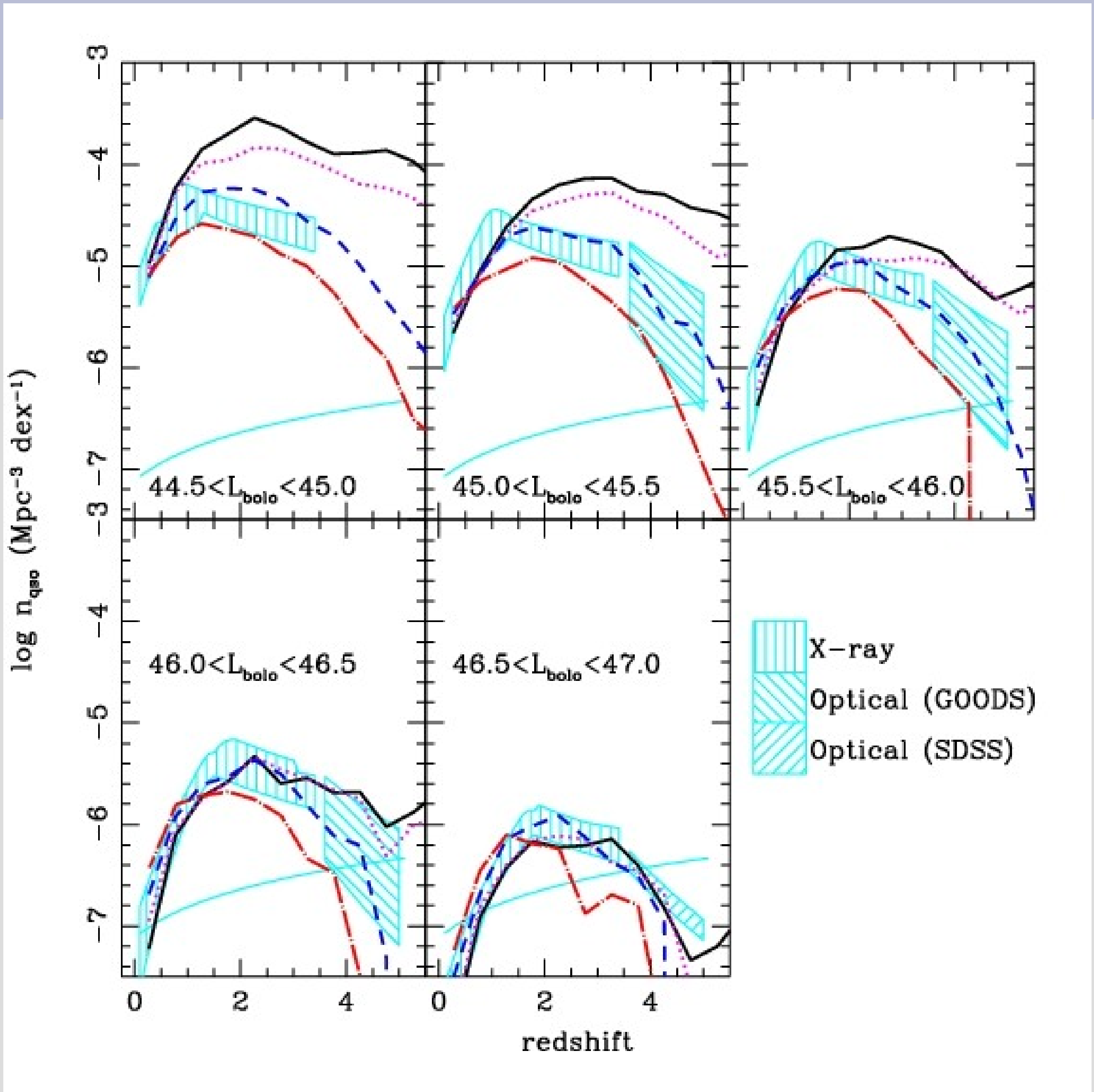




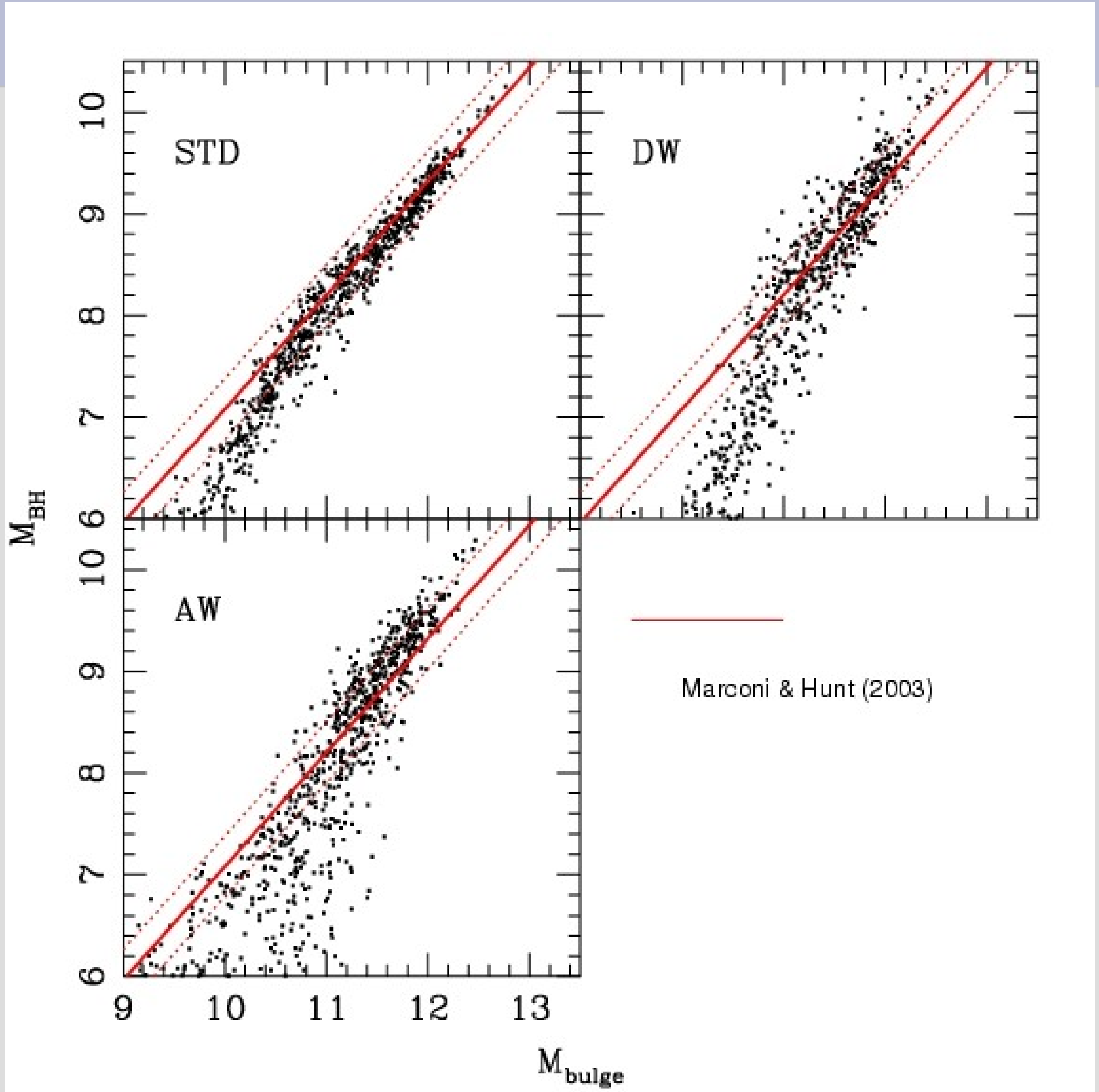
Space Density Evolution



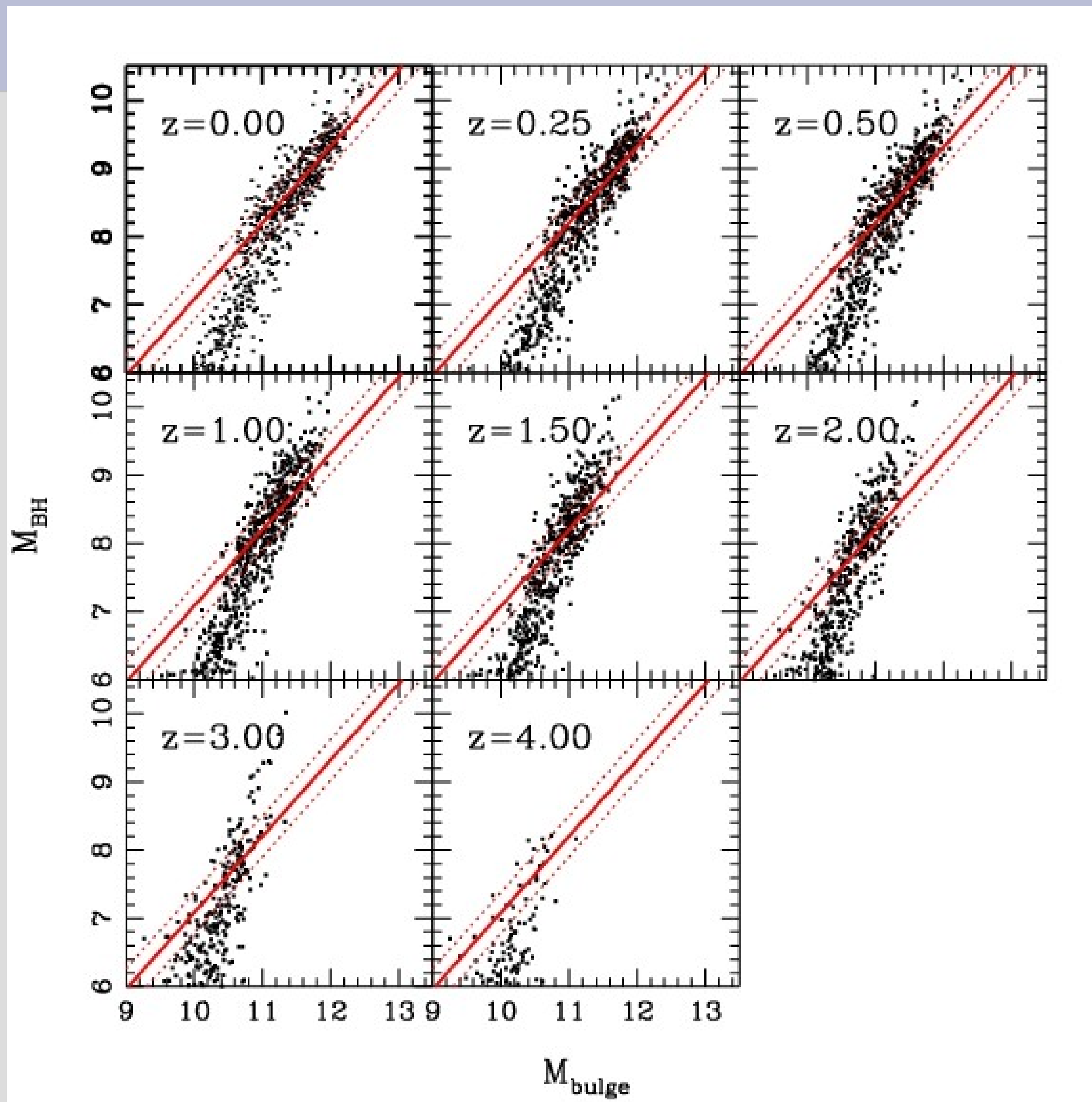
Effect of Kinetic Feedback



Black Hole – Bulge Relation



Black Hole – Bulge Relation



Conclusions

- Models based on Lambda CDM cosmology are able to reproduce the properties of the AGN population

- We are able to reproduce the anti-hierarchical behavior of black hole growth

  - Winds are needed

  - Kinetic stellar feedback