Powering the faint end of the AGN LF

Isabelle Gavignaud

Astrophysical Institute Potsdam

AIP

Lutz Wisotzki (AIP)

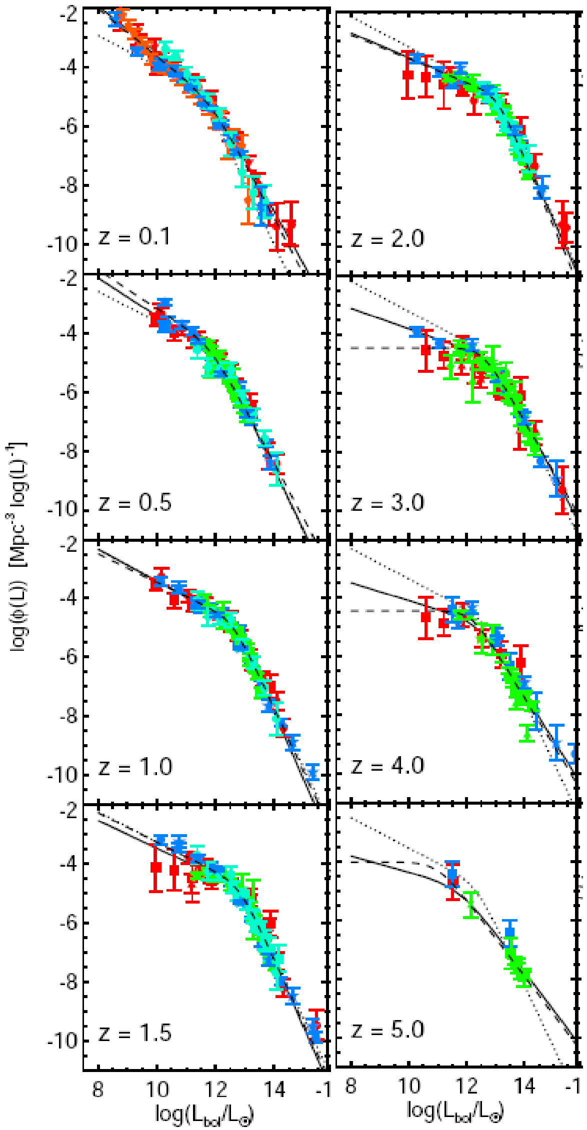
O. Le Fevre and VVDS Team

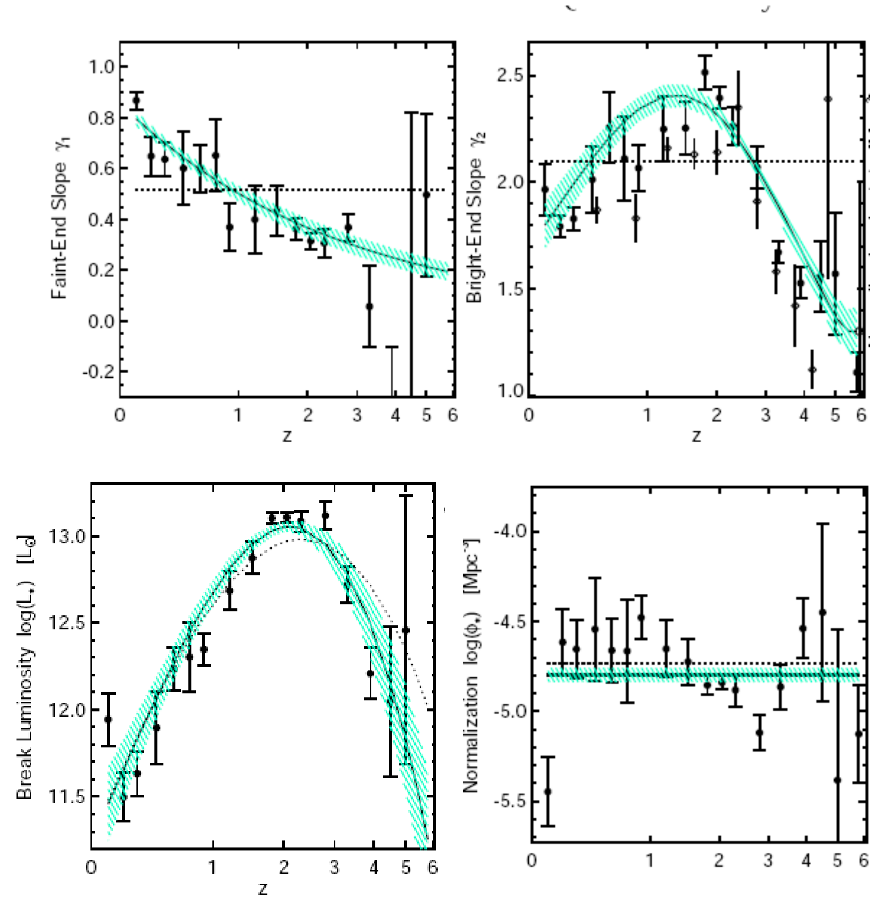
A. Bongiorno (MPE)
S. Paltani Geneva Observatory
G. Zamorani (Bologna)

+

P. Møller ESO (Garching)

The AGN luminosity function

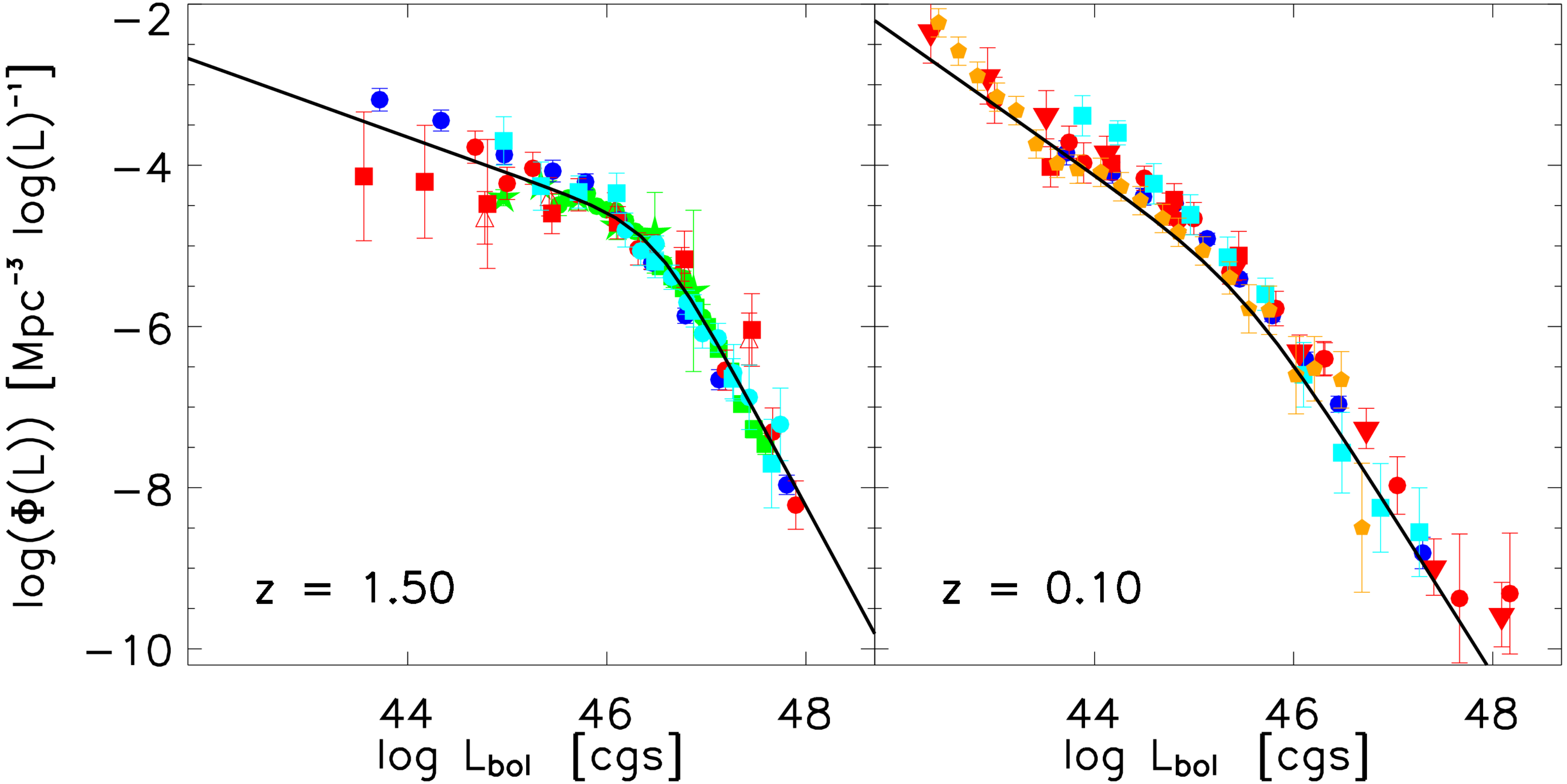




Hard X-ray
Soft X-ray
Optical
Emission Line
Mid-IR

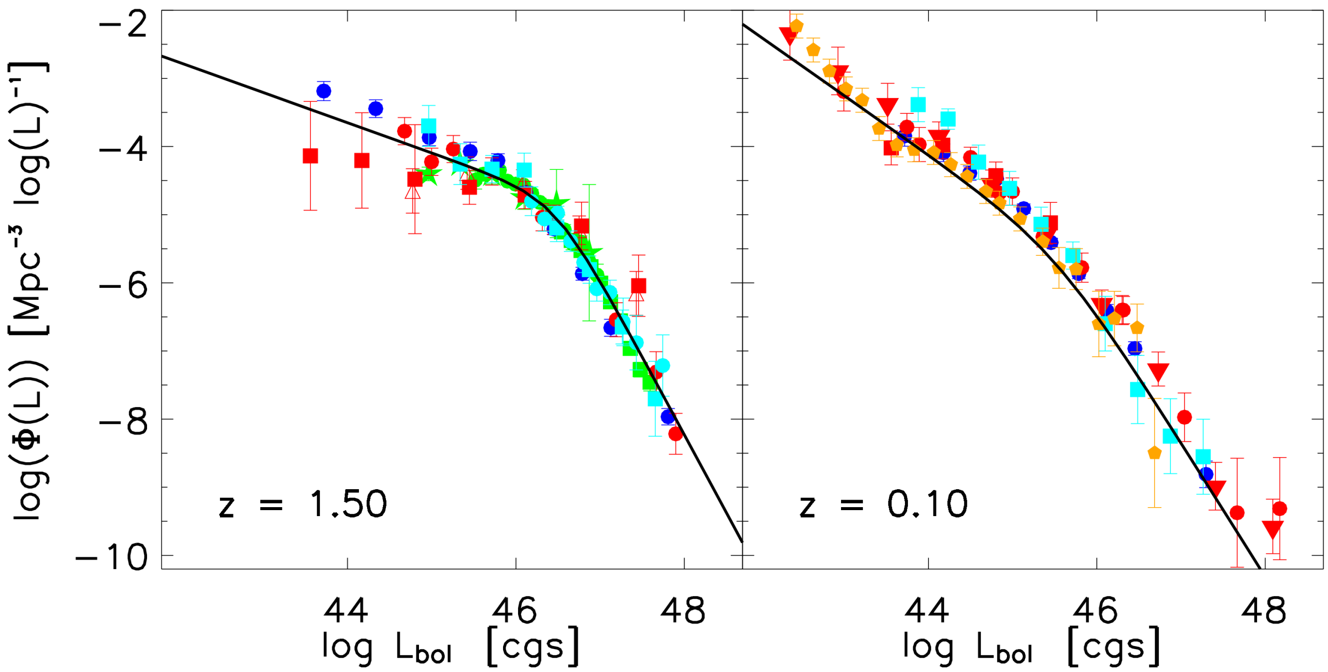
Hopkins et al. 2007

MOTIVATION: Interpret the knee of the AGN luminosity function



Hopkins et al. 2007

MOTIVATION: Interpret the knee of the AGN luminosity function

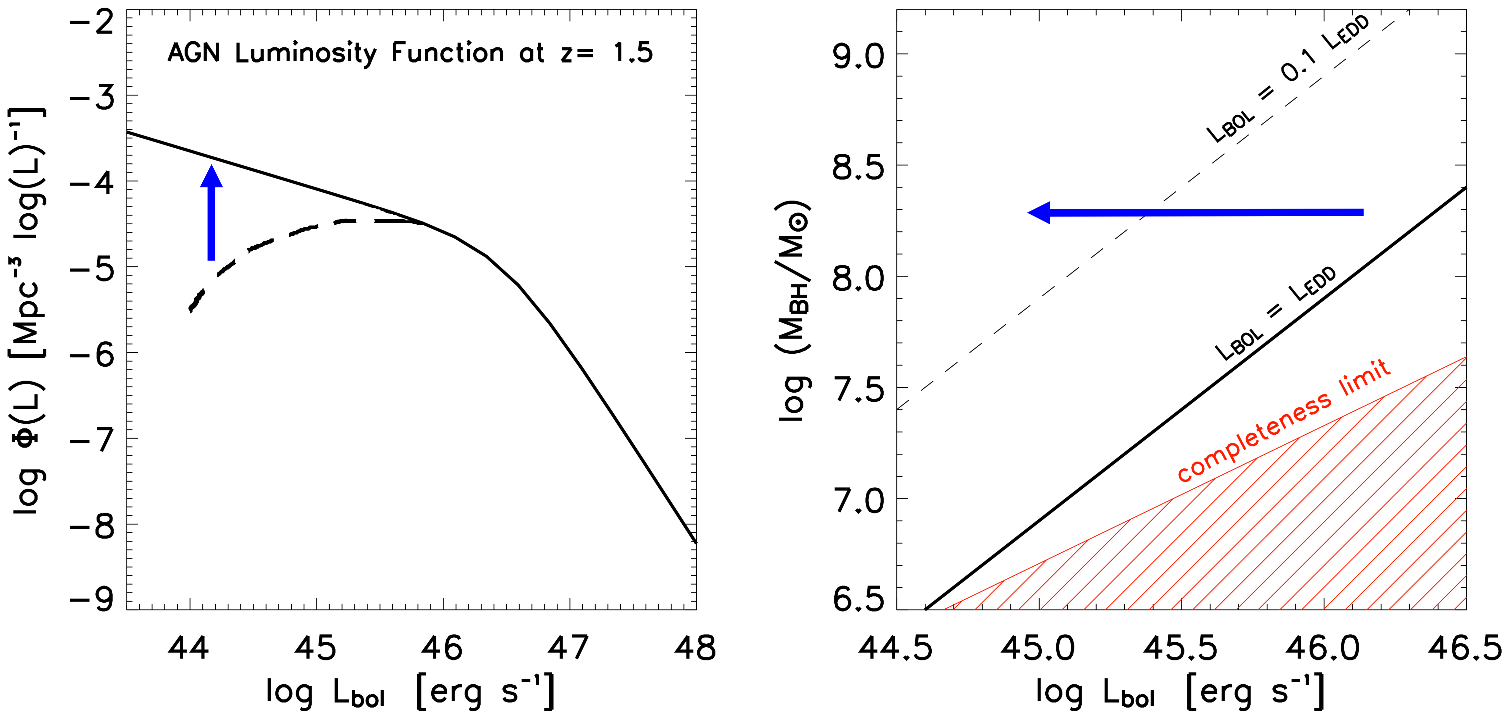


What kind of SMBH are hiding behind low luminosities AGN ?

Massive BH
with low accretion rate

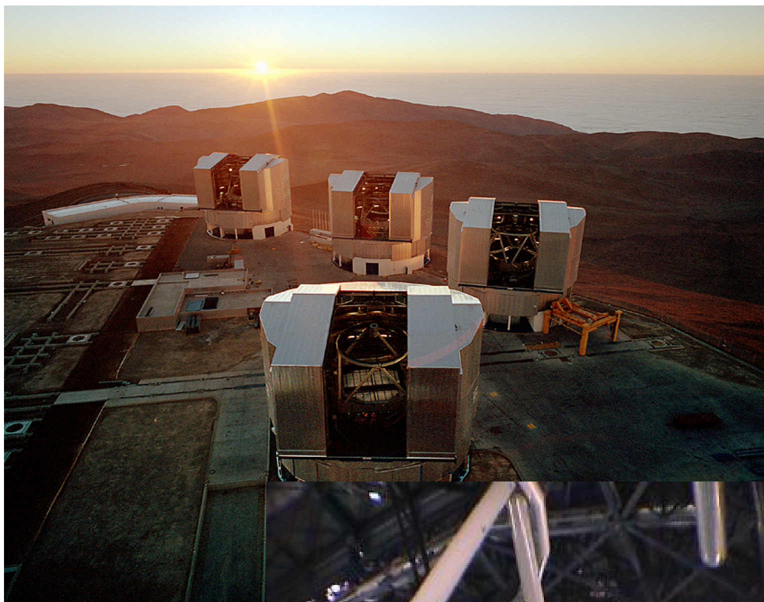
Small BH
with standard accretion rate

COMPARISON: prediction of models

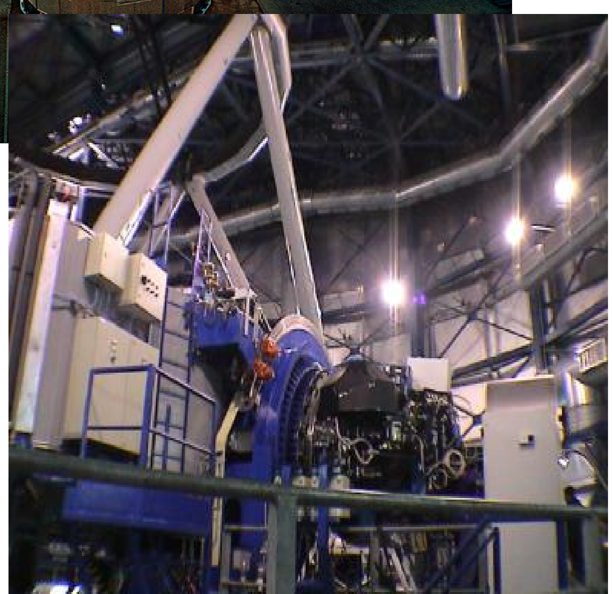


Semi-analytical models where AGN activity is ALWAYS triggered by galaxy major-mergers:
→ Need of a power-law decay to reproduce a rising LF at faint magnitudes
Cattaneo et al. (2001)
→ Numerical simulations of galaxy mergers which incorporate BH growth find that quasar lifetime is longer for lower luminosity AGN (and reproduce the luminosity dependent density evolution LDDE observed for AGN). *Hopkins et al. (2006)*

SAMPLE: The VIMOS VLT Deep Survey



ESO PR Photo 43a/99 (8 December 1999)



Faint galaxy redshift survey

Goal:

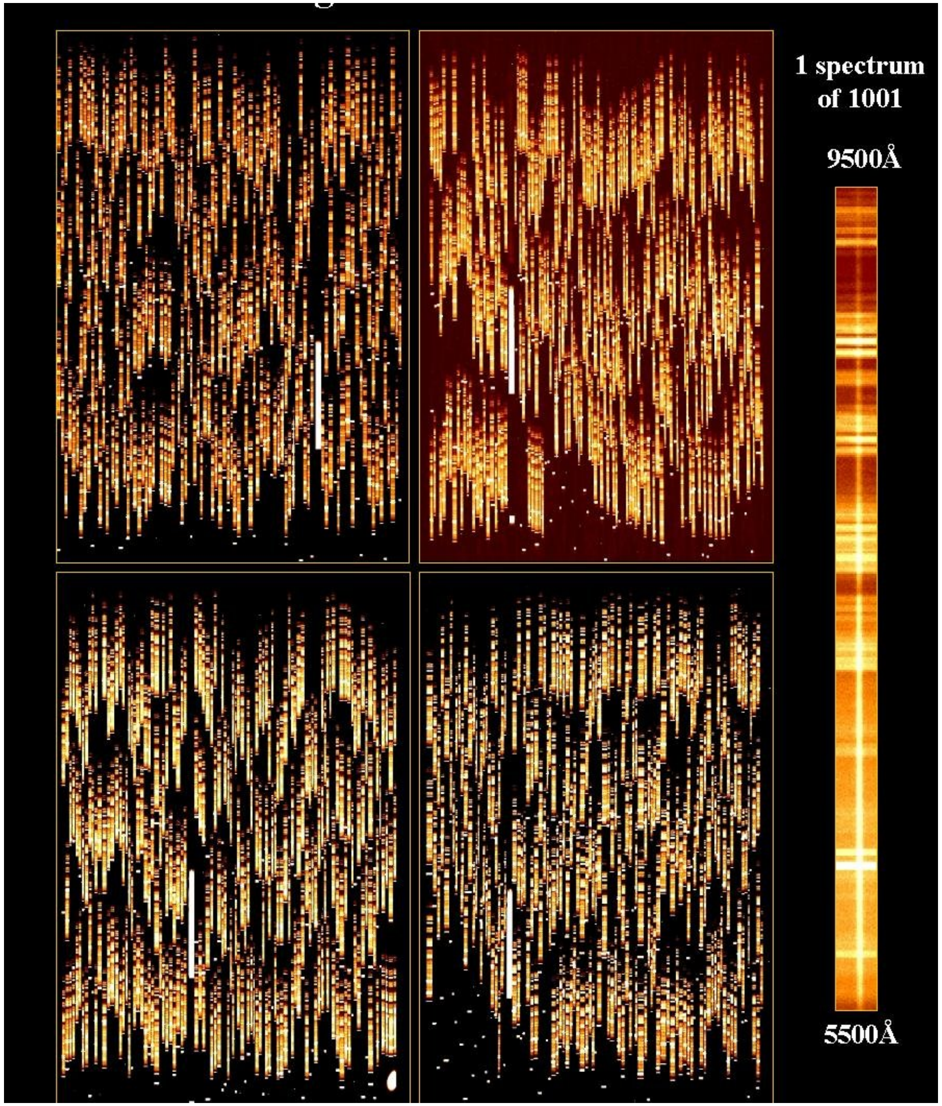
Evolution of galaxies, AGN and large scale structures.

Institutes:

LAM (Marseille), LATT (Toulouse) OABo/IRA (Bologna), IASF/OABr (Milan), OAC (Napoli), OAR(Roma)

→Spectroscopic follow-up @ESO with VIMOS

SAMPLE: The VIMOS VLT Deep Survey



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→**Spectroscopic follow-up @ESO with VIMOS**

$I_{AB} < 24$: VVDS-Deep *Le Fèvre et al. 2005*
11 000 spectra in 0.6 deg^2

$I_{AB} < 22.5$: VVDS-Wide *Garilli et al. 2007*
30 000 spectra in 4.5 deg^2

The VIMOS VLT Deep Survey

Deep sample I<24

0226-04
~0.5 deg2
9 600 spectra

CDFS
~0.15 deg2
1 700 spectra

Wide sample I<22.5

1400+05
~0.9 deg2
6 000 spectra

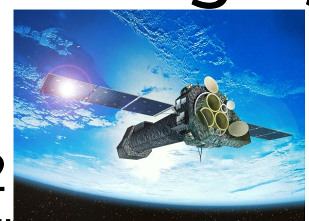
1003+01
~0.6 deg2
4 000 spectra

2217-00
~3.0 deg2
20 000 spectra

Public data release

VVDS Imaging Survey: *U* ***B V R I*** *J K*

+



0226-04
~0.5 deg2
9 600 spectra

CDFS
~0.15 deg2
1 700 spectra

2217-00
~3.0 deg2
20 000 spectra

http://cencos.oamp.fr/

SAMPLE: The VIMOS VLT Deep Survey

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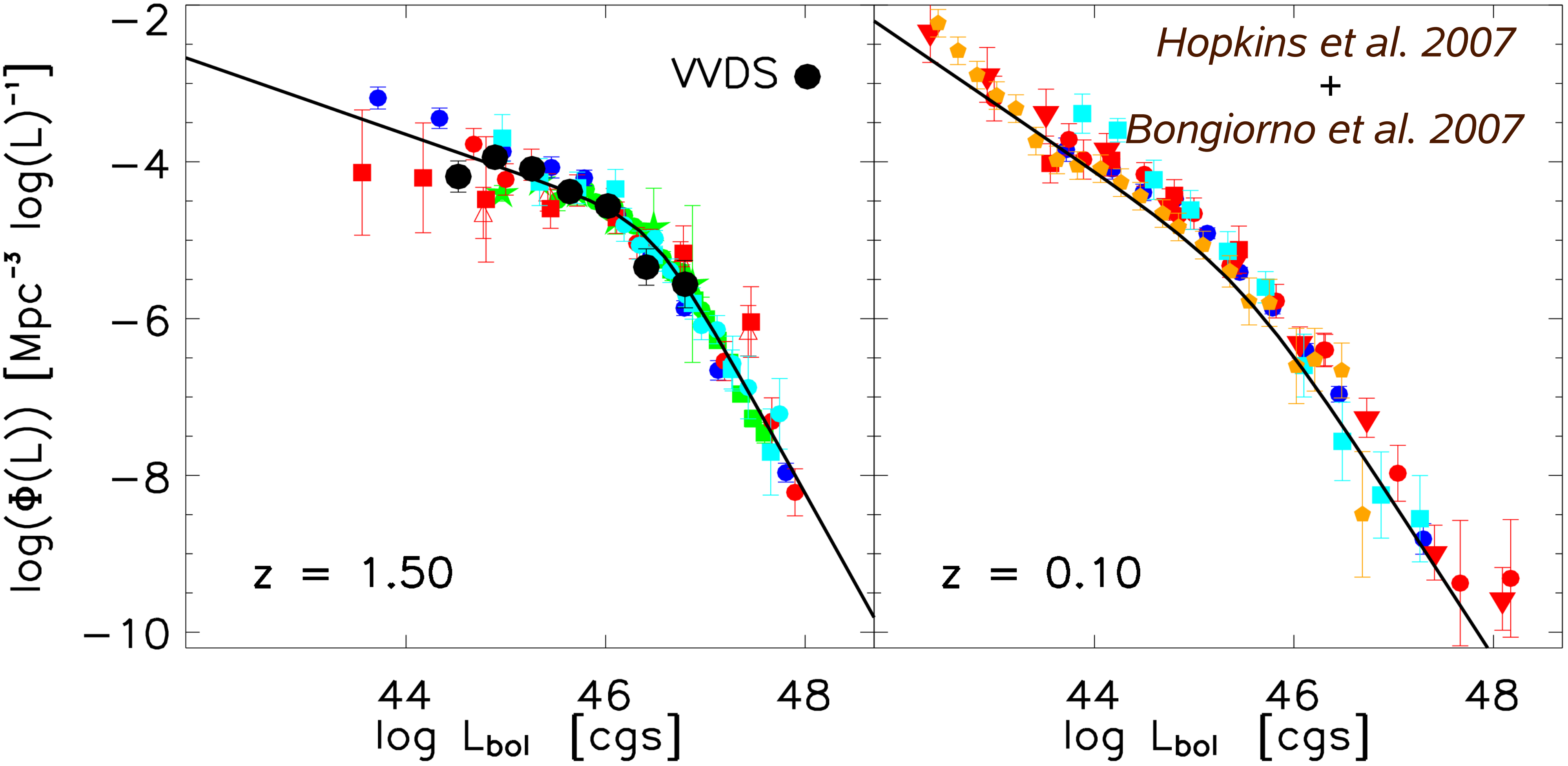
→Faint spectroscopical sample sample of 300 AGN

→ Free of morphological/colour selection;
→ I_{AB}<22.5 & I_{AB}<24: Deep counterpart of SDSS (i* < 19) and 2Qz (bj<20.8) and spectroscopical equivalent to COMBO-17 (192 AGN, z > 1.2, R < 24)
→ 0 < z < 5
→ FORS follow-up spectroscopy of most of degenerate redshifts (single broad emission line objects).

Gavignaud et al. 2006

SAMPLE: The VIMOS VLT Deep Survey

→Faint spectroscopical sample sample of 300 AGN



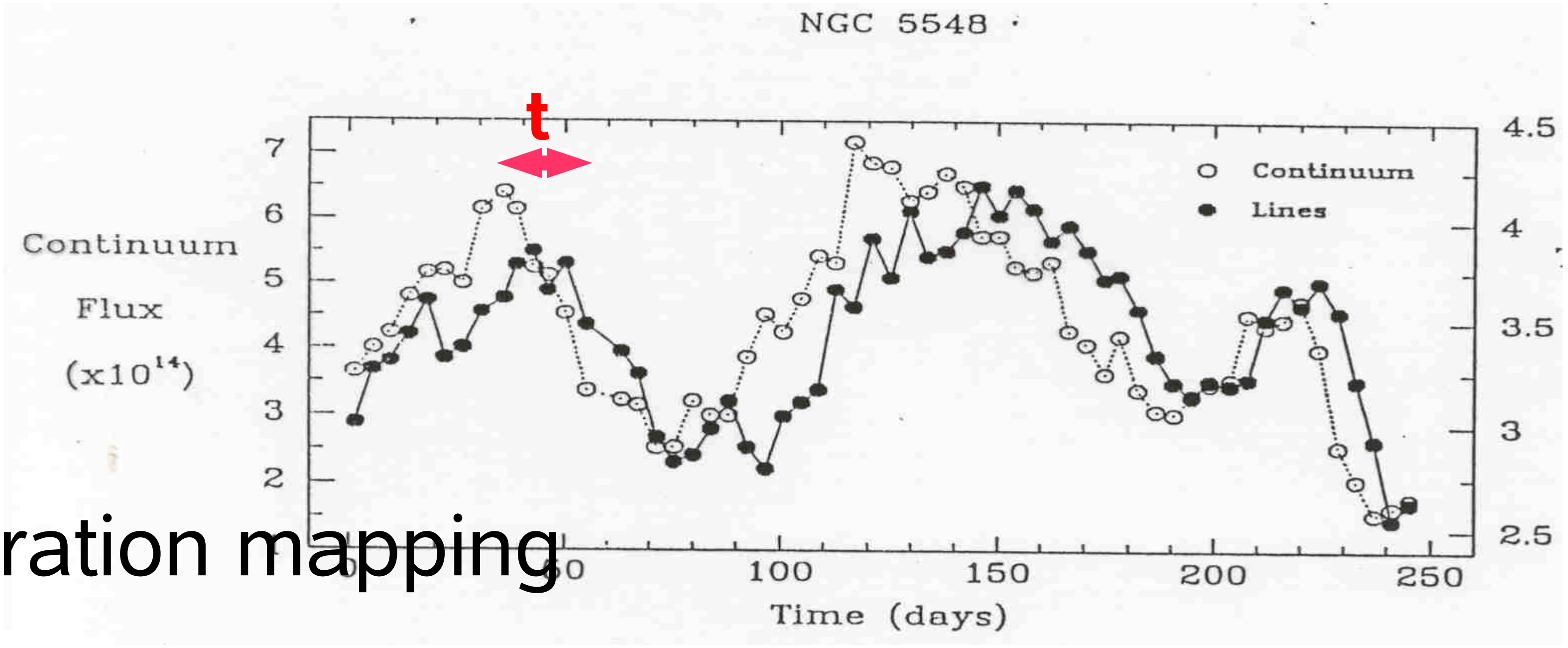
Weighing Black Holes

Assuming that the gas motion in the BLR is dominated by gravity

<u>Virial Relation</u>: $M_{BH} \sim f\, R\, V^2$

<u>Size of the broad Line Region</u>:
Line emission is delayed by
$R \sim c\, t$
from the continuum variation

<u>Broad Emission Line width</u>
FWHM, σ



Reverberation mapping

Weighing Black Holes

Assuming that the gas motion in the BLR is dominated by gravity

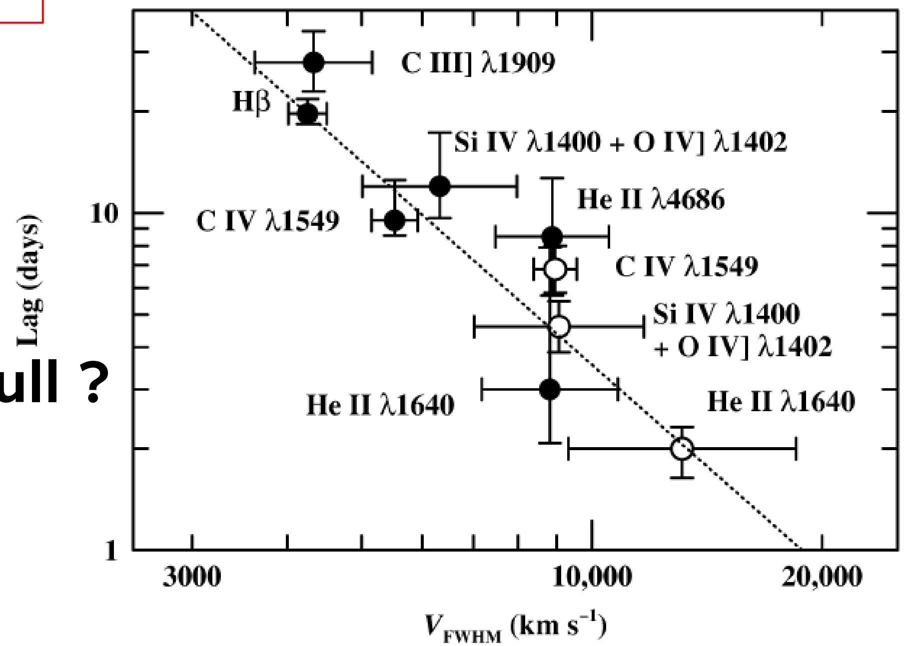
Virial Relation: $M_{BH} \sim f R V^2$

Broad Emission Line width
FWHM, σ

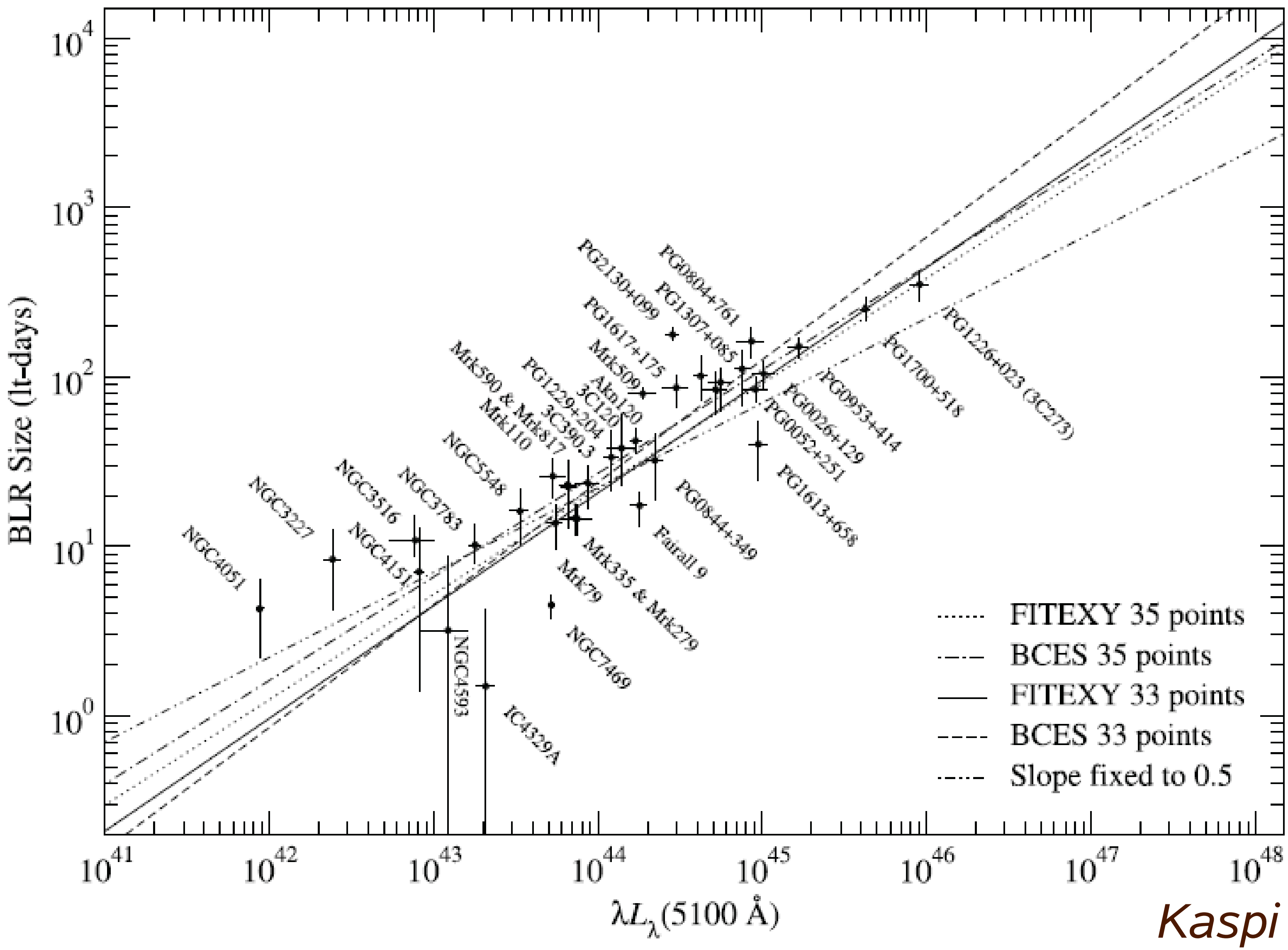
Size of the broad Line Region:
Line emission is delayed by
$R \sim c\,t$
from the continuum variation

Peterson & Wandel 1999

Is the virial assumption meaningfull ?
→ Indeed for different lines
$R \sim V^{-1/2}$



Weighing Black Holes



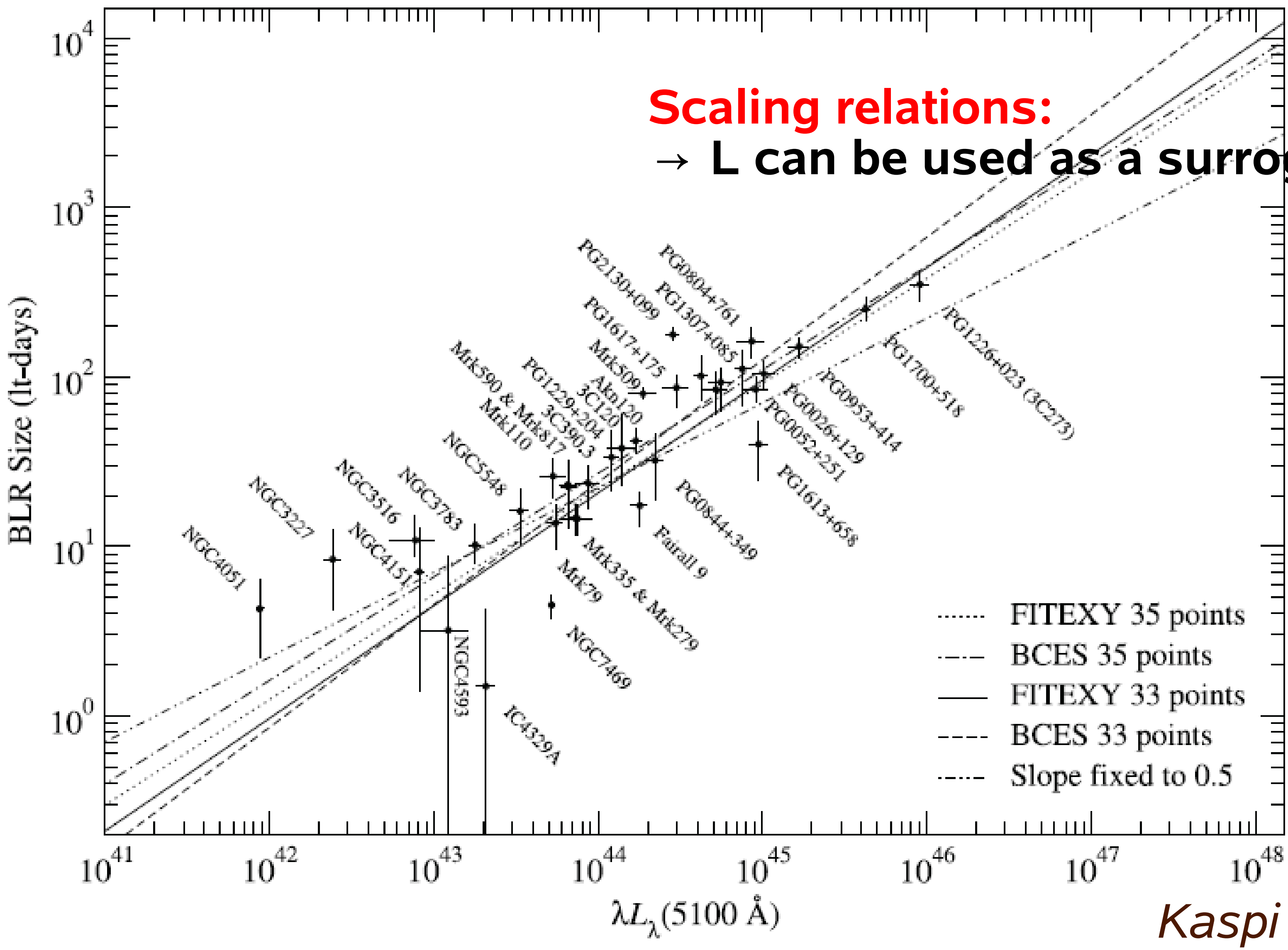
Kaspi 2000, 2005

Weighing Black Holes

AIP

Scaling relations:

→ L can be used as a surrogate for R



Kaspi 2000, 2005

Weighing Black Holes

AIP

Assuming that the gas motion in the BLR is dominated by gravity

Virial Relation: $M_{BH} \sim f\, R\, V^2$

Broad Emission Line width

FWHM, σ

Size of the broad Line Region:

$R \sim L^{\sim 0.5}$

For MgII: $\log M_{BH} = 2 \log FWHM_{1000} + 0.62 \log (L_{44,3000}) + 6.51$

Mc Lure & Dunlop (2004)

For C IV: $\log M_{BH} = 2 \log \sigma_{1000} + 0.53 \log (L_{44,1350}) + 6.73$

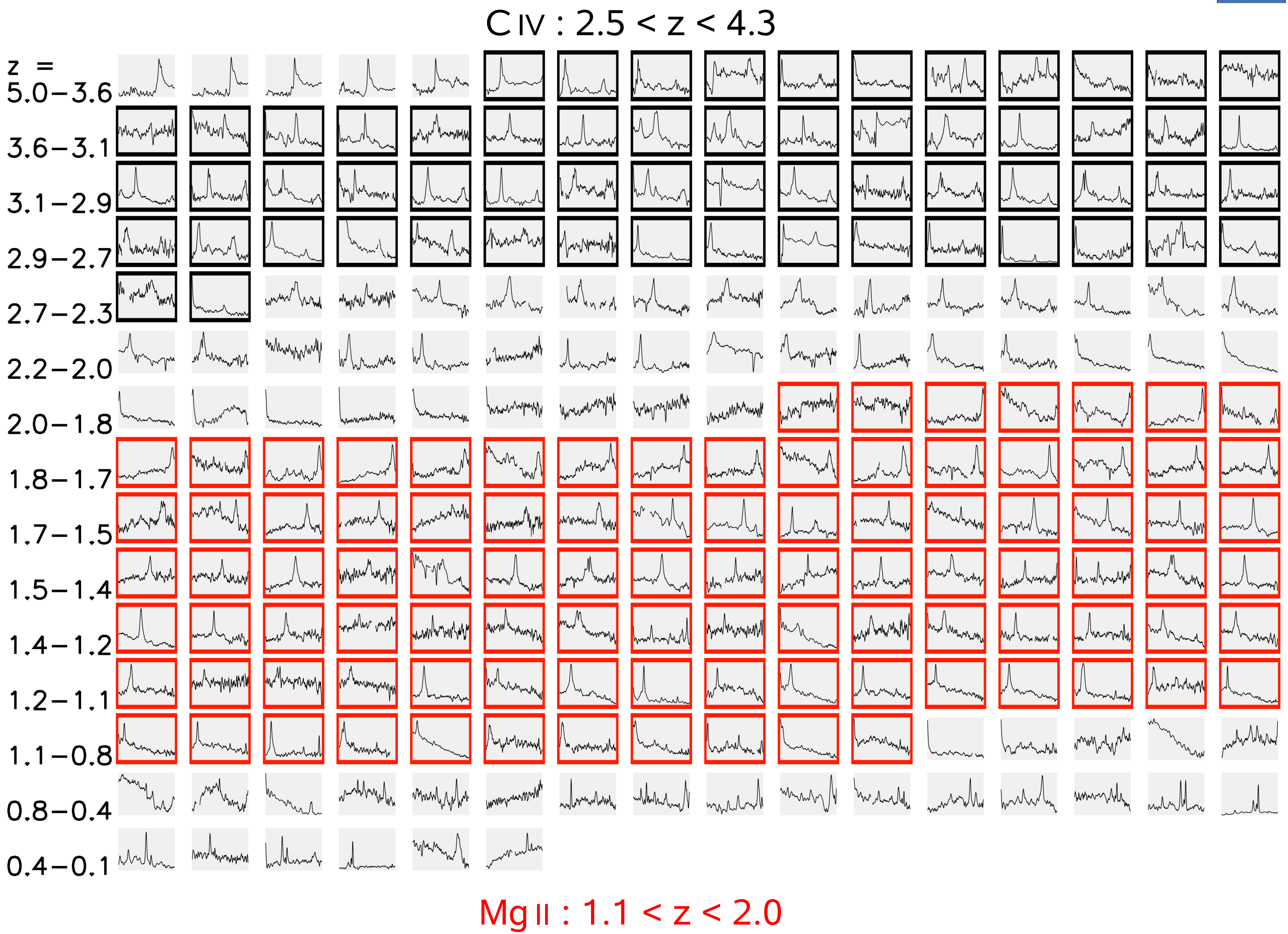
Vestergaard & Peterson (2006)

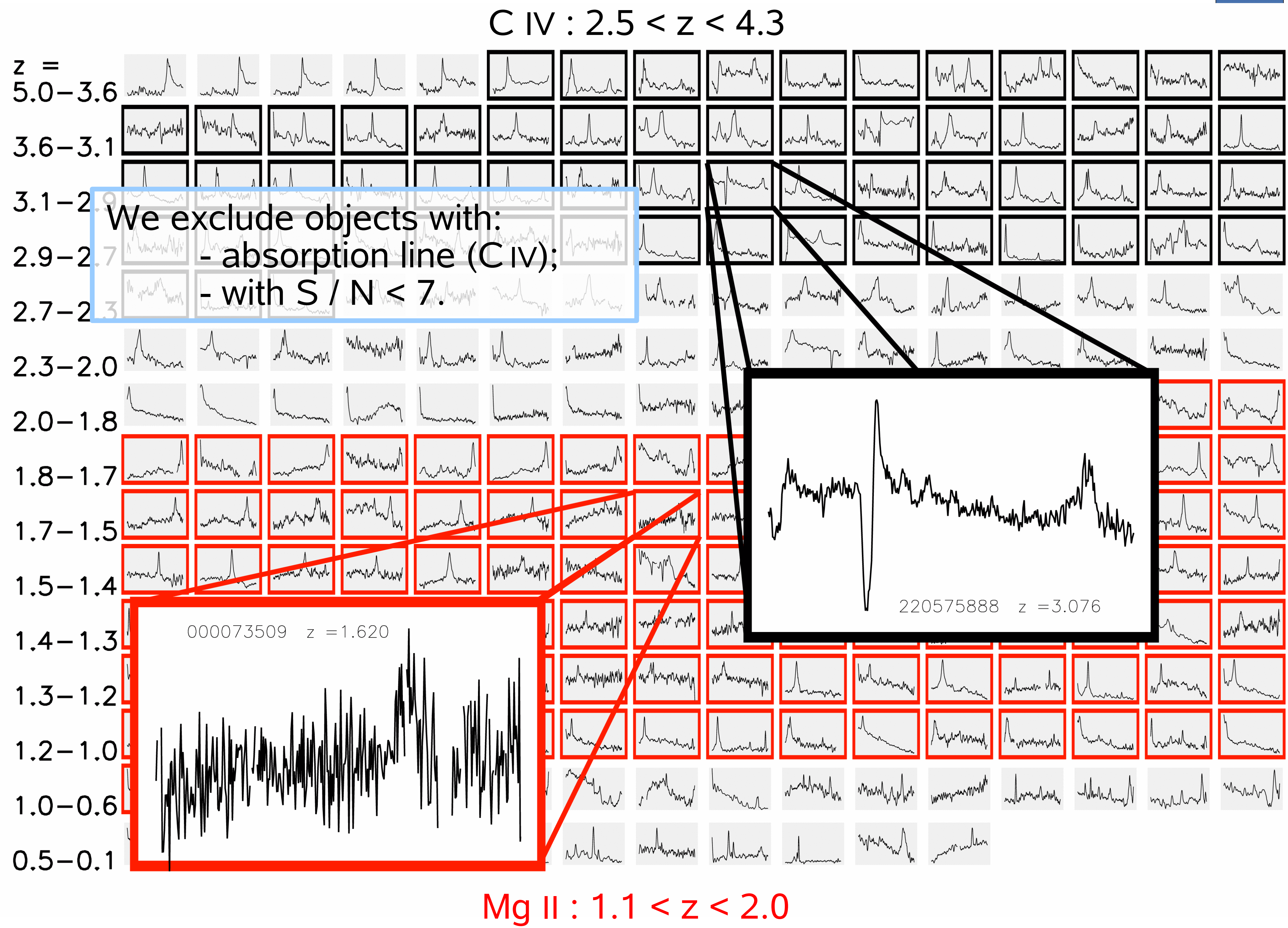
Luminosity dependant bolometric corrections:

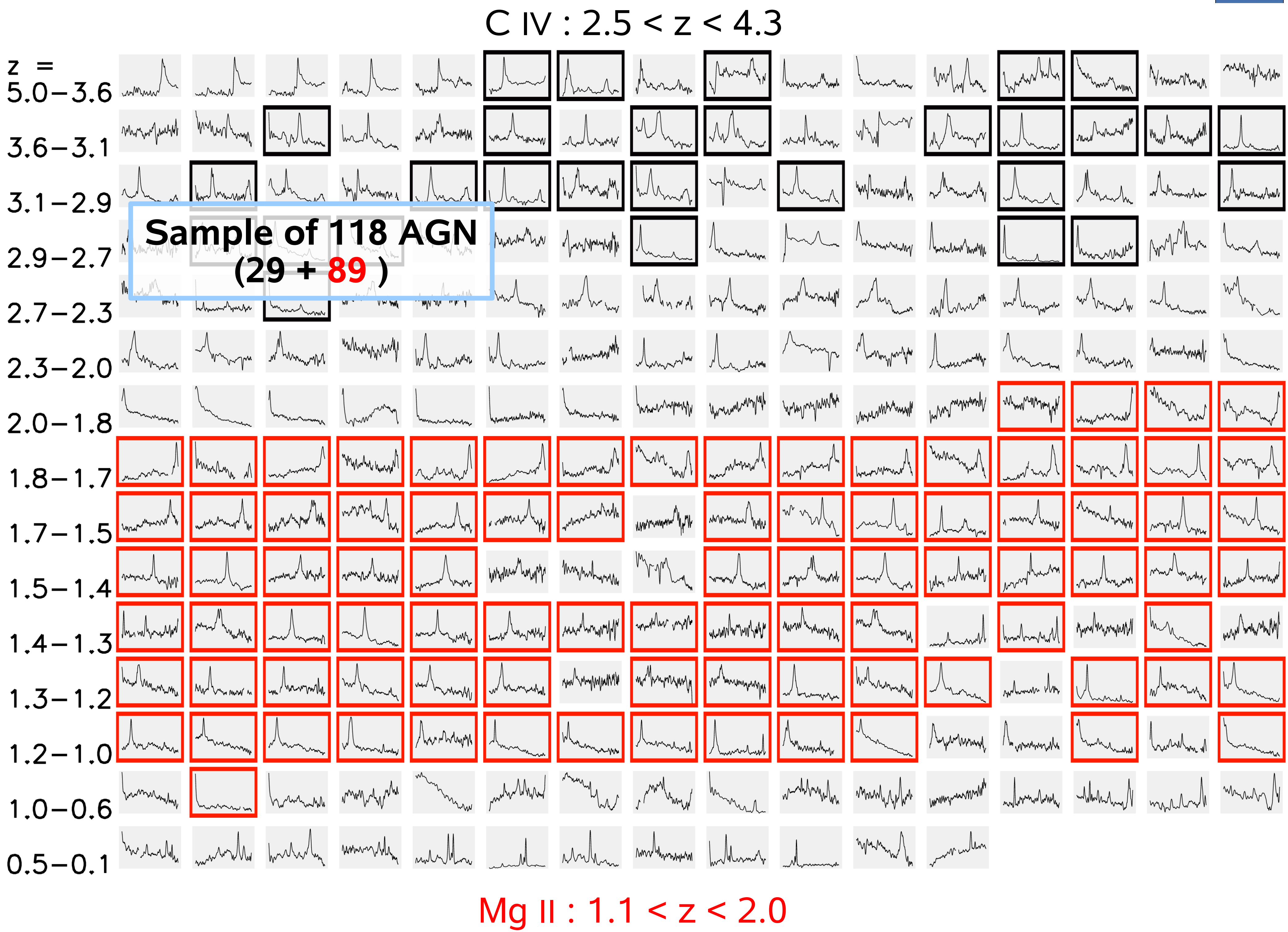
$f_{bol}(3000\ A) \sim 6.5$

$f_{bol}(1350\ A) \sim 4$

Observed wavelength = 5500 – 9200 A


C IV : 2.5 < z < 4.3
z =
5.0−3.6
3.6−3.1
3.1−2.9
2.9−2.7
2.7−2.3
2.2−2.0
2.0−1.8
1.8−1.7
1.7−1.5
1.5−1.4
1.4−1.2
1.2−1.1
1.1−0.8
0.8−0.4
0.4−0.1
Mg II : 1.1 < z < 2.0


C IV : 2.5 < z < 4.3
z =
5.0−3.6
3.6−3.1
3.1−2.9
2.9−2.7
2.7−2.3
2.3−2.0
2.0−1.8
1.8−1.7
1.7−1.5
1.5−1.4
1.4−1.3
1.3−1.2
1.2−1.0
1.0−0.6
0.5−0.1
We exclude objects with:
- absorption line (C IV);
- with S / N < 7.
220575888 z =3.076
000073509 z =1.620
Mg II : 1.1 < z < 2.0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5.0−3.6
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2.7−2.3
2.3−2.0
2.0−1.8
1.8−1.7
1.7−1.5
1.5−1.4
1.4−1.3
1.3−1.2
1.2−1.0
1.0−0.6
0.5−0.1
Sample of 118 AGN
(29 + 89)
Mg II : 1.1 < z < 2.0

RESULTS: M_{BH} and L/L_{EDD}

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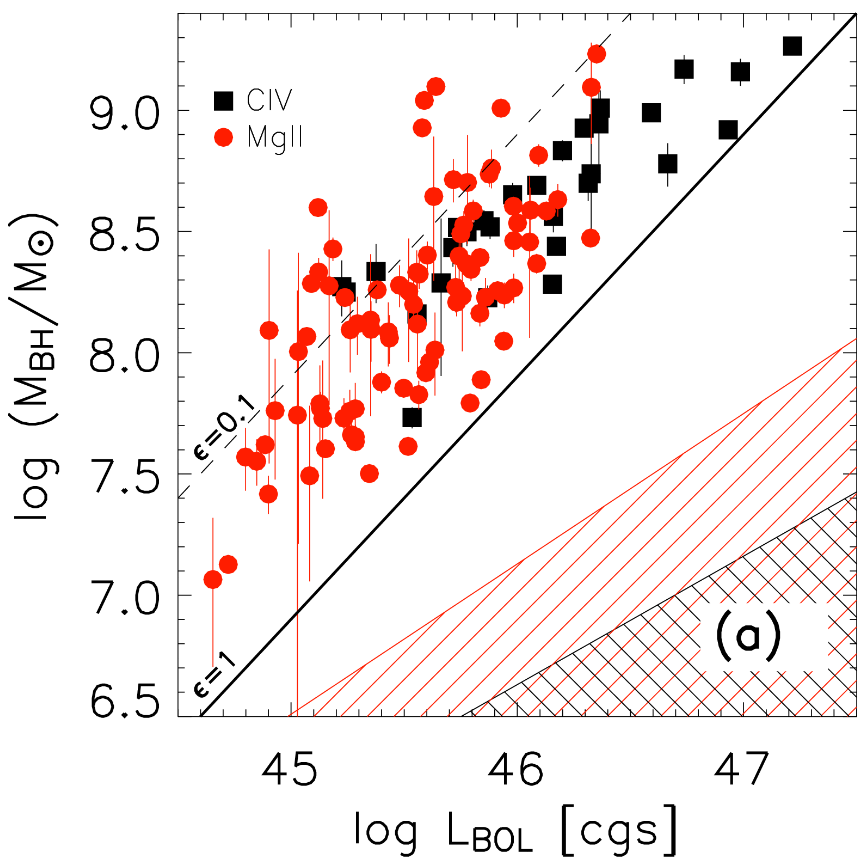
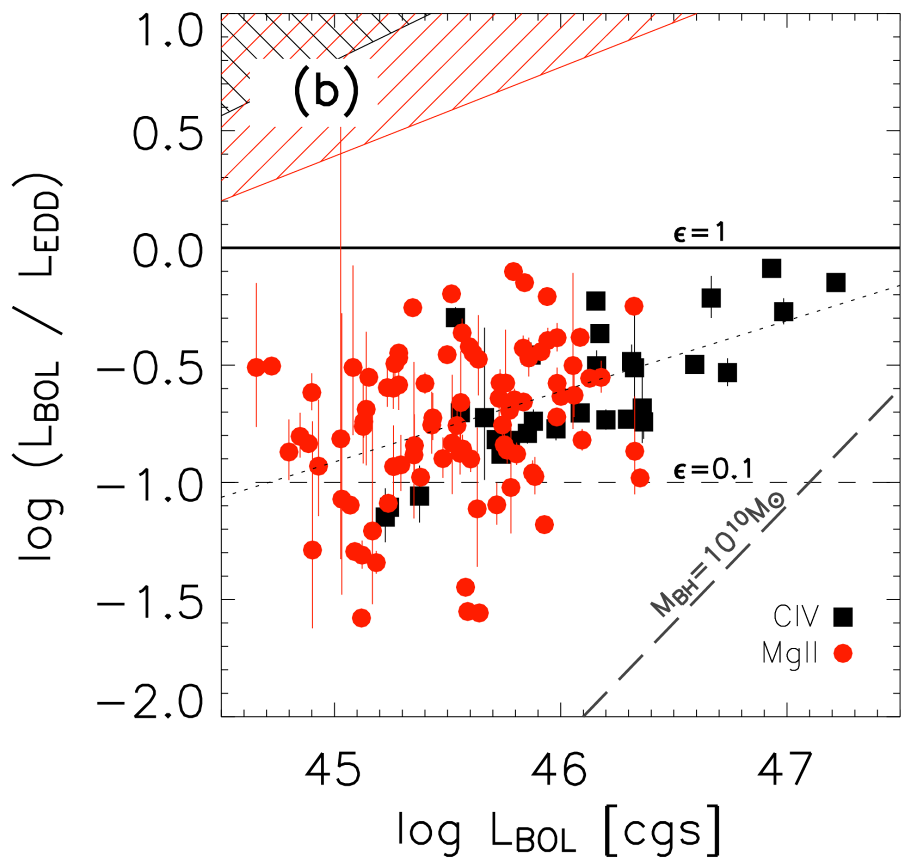
M_{BH} versus luminosity



Accretion rate versus luminosity



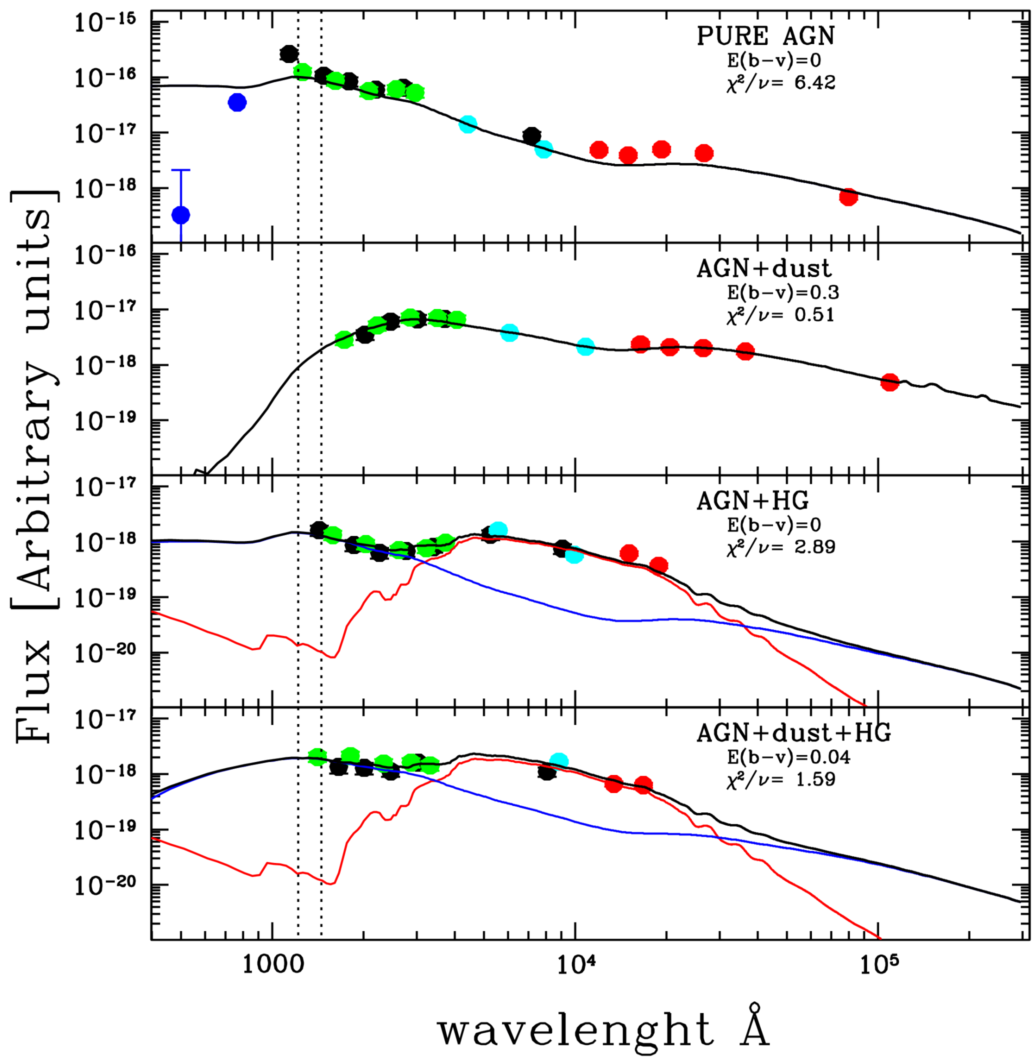
RESULTS: Possible biases

- Host galaxy contamination ?
- Incertitude on the index α to estimate R from L

RESULTS: Possible biases

- Host galaxy contamination

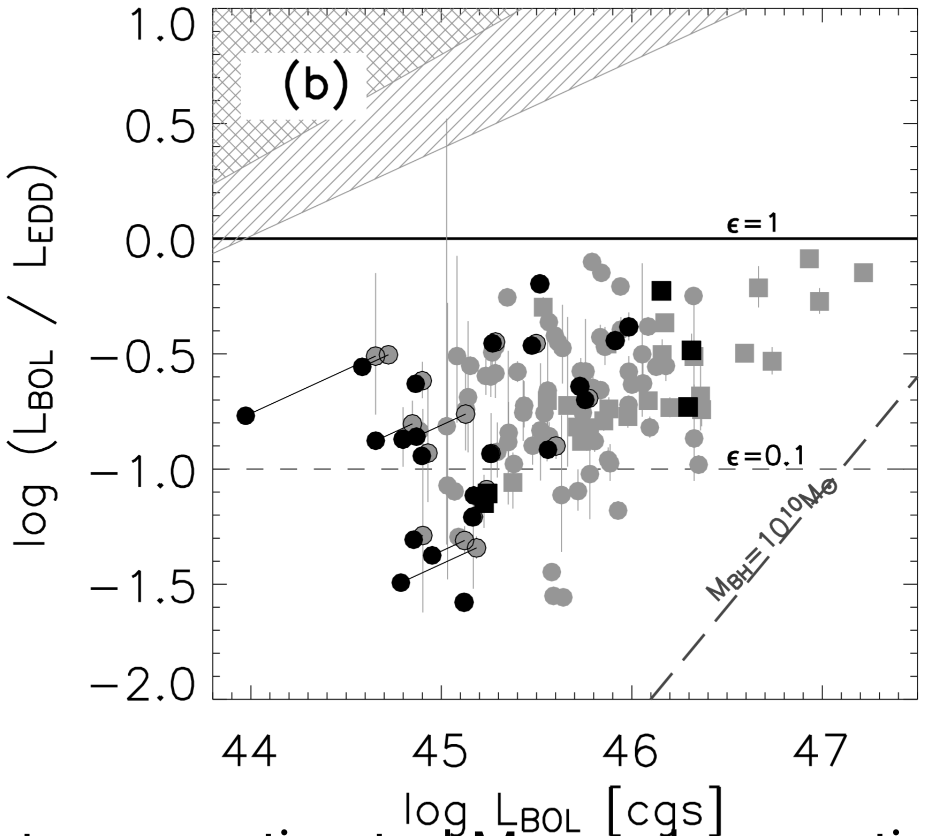
We use the multi-wavelength data available in F02 to estimate the host contamination



Bongiorno et al. 2007

RESULTS: Possible biases

- Host galaxy contamination ?



This would lead to overestimated M_{BH} and overestimated L/L_{EDD}

→ **Our results are conservative**

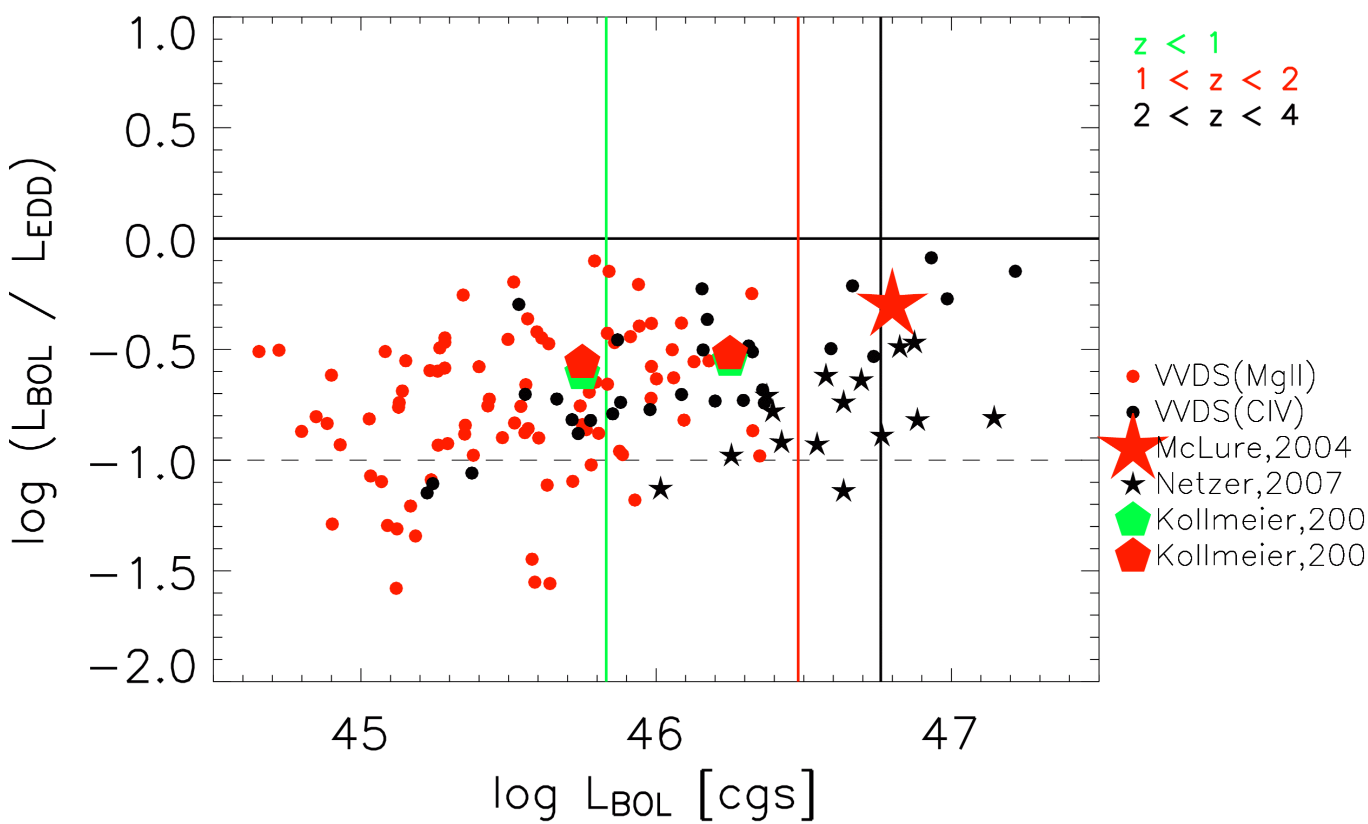
RESULTS: Possible biases

AIP

- Host galaxy contamination ?
  → Our result are conservative

- Incertitude on the index α to estimate R from L
  Values in the literature from 0.4 to 0.8:
  → it is affecting our results

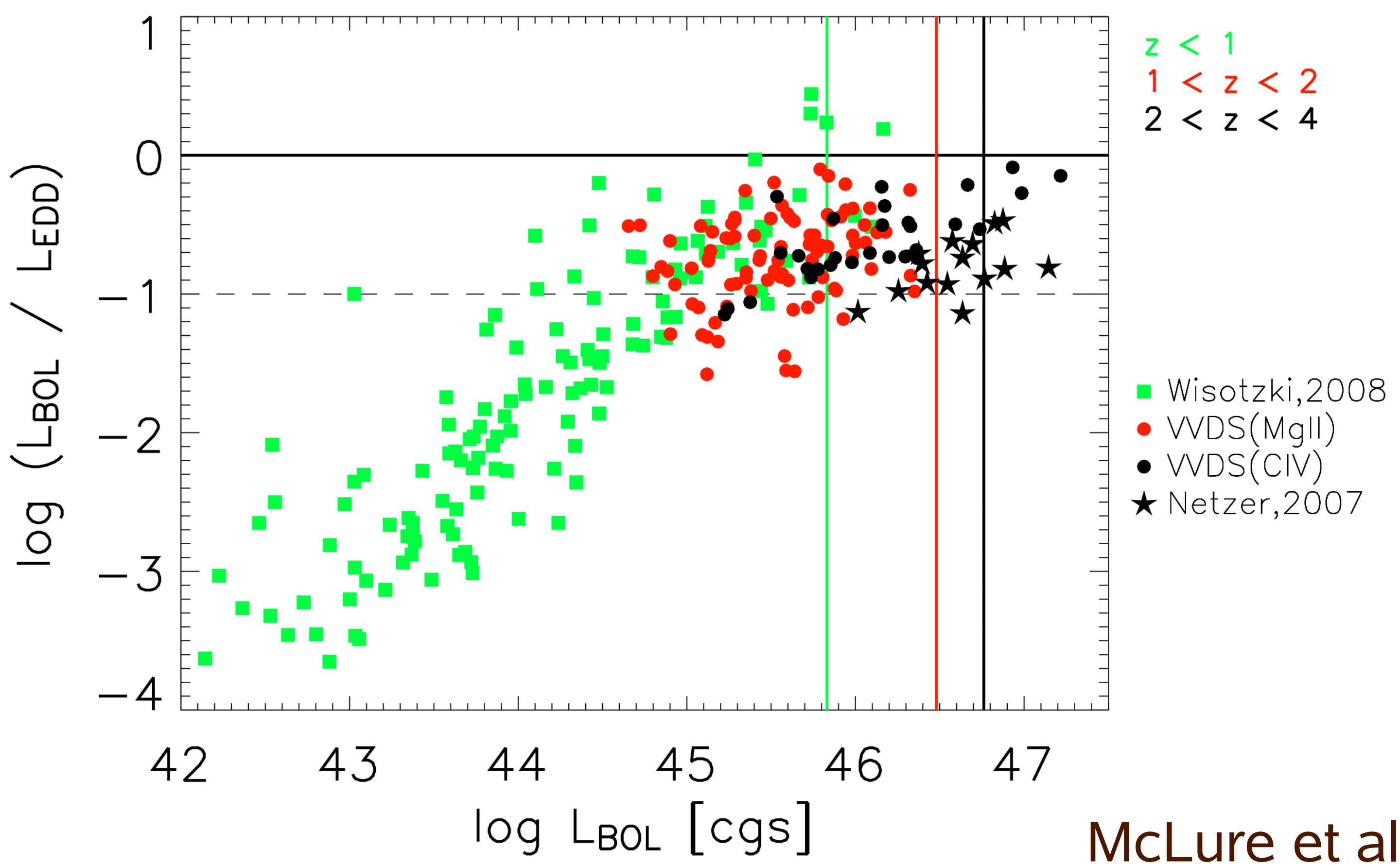
COMPARISON: other surveys



McLure et al. 2004
Kollmeier et al. 2006
Netzer et al. 2007.

COMPARISON: other surveys

AIP



McLure et al. 2004
Kollmeier et al. 2006
Netzer et al. 2007
Wisotzki et al. in prepa.

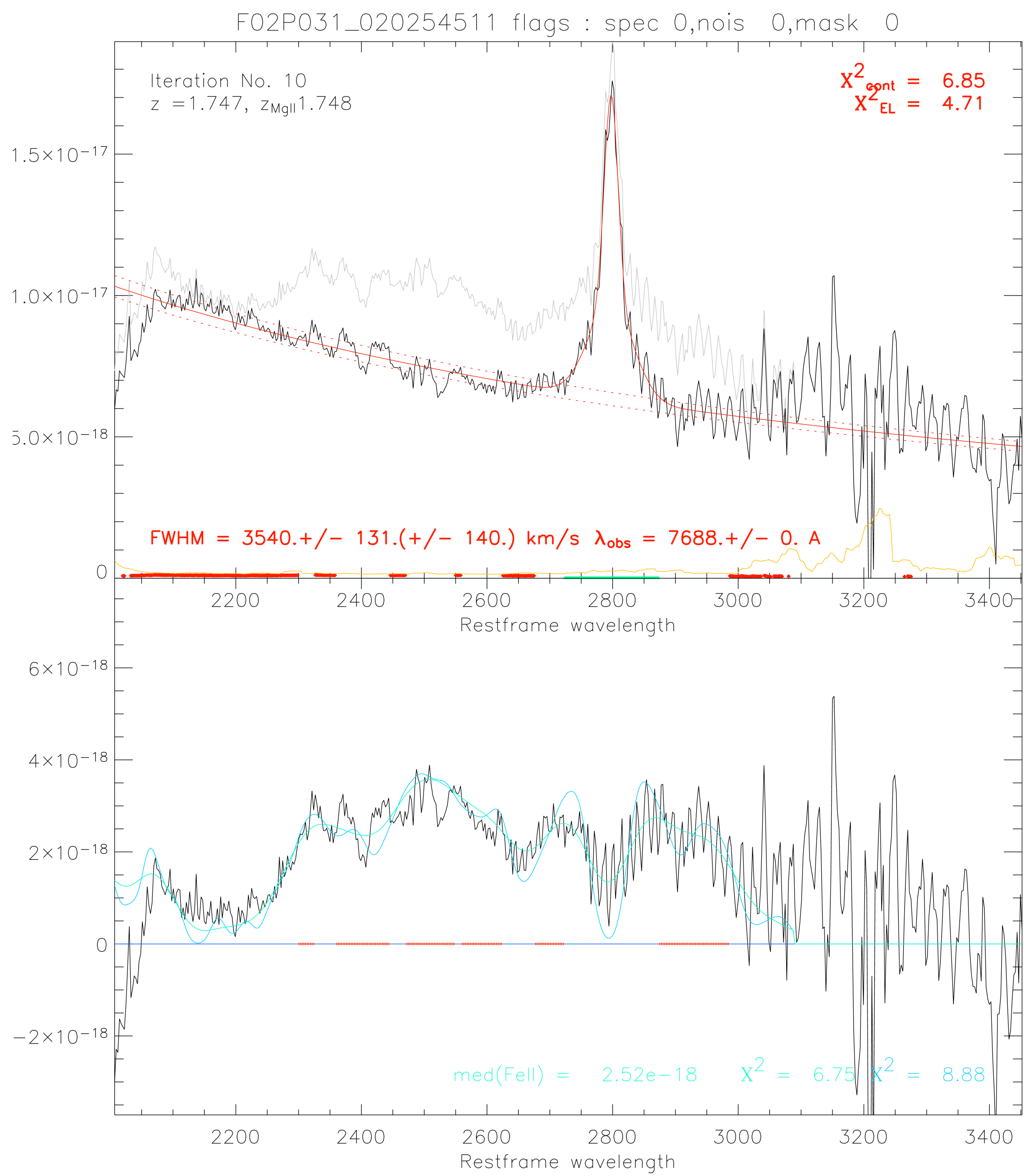
CONCLUSION

- Optical sample of faint AGN free of colour and morphological biases;

- Evidence for a population of half-starved black holes, at ~1 magnitude fainter than the knee of the LF.

FUTURE WORK

- Study the optical variability (with CFHTLS) and the host galaxies (with HST) of these faint AGN.


F02P031_020254511 flags : spec 0,nois 0,mask 0
Iteration No. 10
z =1.747, z_MgII 1.748
X²cont = 6.85
X²EL = 4.71
1.5×10⁻¹⁷
1.0×10⁻¹⁷
5.0×10⁻¹⁸
0
FWHM = 3540.+/- 131.(+/- 140.) km/s λobs = 7688.+/- 0. A
2200 2400 2600 2800 3000 3200 3400
Restframe wavelength
6×10⁻¹⁸
4×10⁻¹⁸
2×10⁻¹⁸
0
−2×10⁻¹⁸
med(FeII) = 2.52e−18 X² = 6.75 X² = 8.88
2200 2400 2600 2800 3000 3200 3400
Restframe wavelength