X-ray selected Obscured AGN in the COSMOS field

Marcella Brusa (MPE)

With help from

F. Civano, V. Mainieri, A. Comastri, F. Fiore, G. Zamorani

+

XMM-COSMOS team: G. Hasinger, R. Gilli, C. Vignali, N. Cappelluti, H. Boehringer, H. Brunner, M. Elvis, A. Finoguenov, L. Guzzo, R. Griffiths, C. Impey, O. Le Fevre, S. Lilly, G. Matt, T. Miyaji, N. Scoville, J. Silverman, M. Urry

+

P. Capak, H. McCracken, D. Thompson + (optical catalogs)

M. Salvato, O. Ilbert, H. Aussel + S-COSMOS (Spitzer data)

J. Trump + IMACS, S.Lilly + zCOSMOS (redshifts)

Evolution of Obscured AGN – why bother?

- Obscured AGN are needed:

  - to reproduce the X-ray background peak
    (Setti & Woltjer 1989, Comastri et al. 1995 etc.)

  - to reconcile the local BH mass function with mass accreted on BH
    (e.g. Fabian & Iwasawa 1999, Marconi et al. 2004)

- Evolution of AGN →

  - AGN provide necessary feedback to stop star formation

Motivation of the XMM-COSMOS project

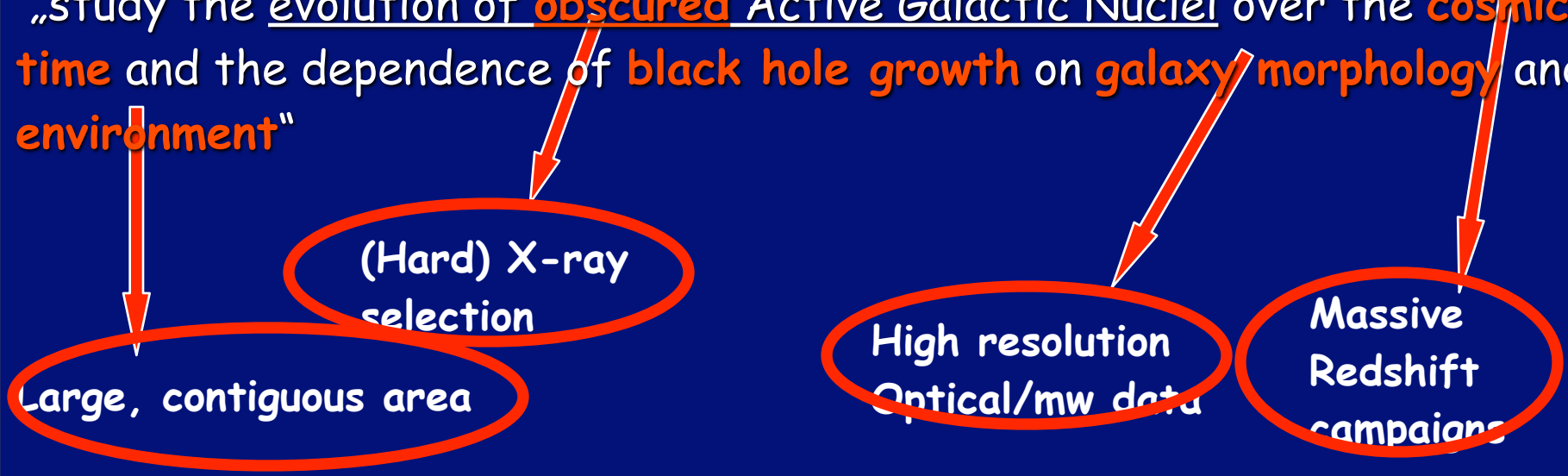
(One of the) Main goal of the XMM-Newton Wide field survey in the COSMOS field is:

„study the evolution of **obscured** Active Galactic Nuclei over the **cosmic time** and the dependence of **black hole growth** on **galaxy morphology** and **environment**"

Motivation of the XMM-COSMOS project

(One of the) Main goal of the XMM-Newton Wide field survey in the COSMOS field is:

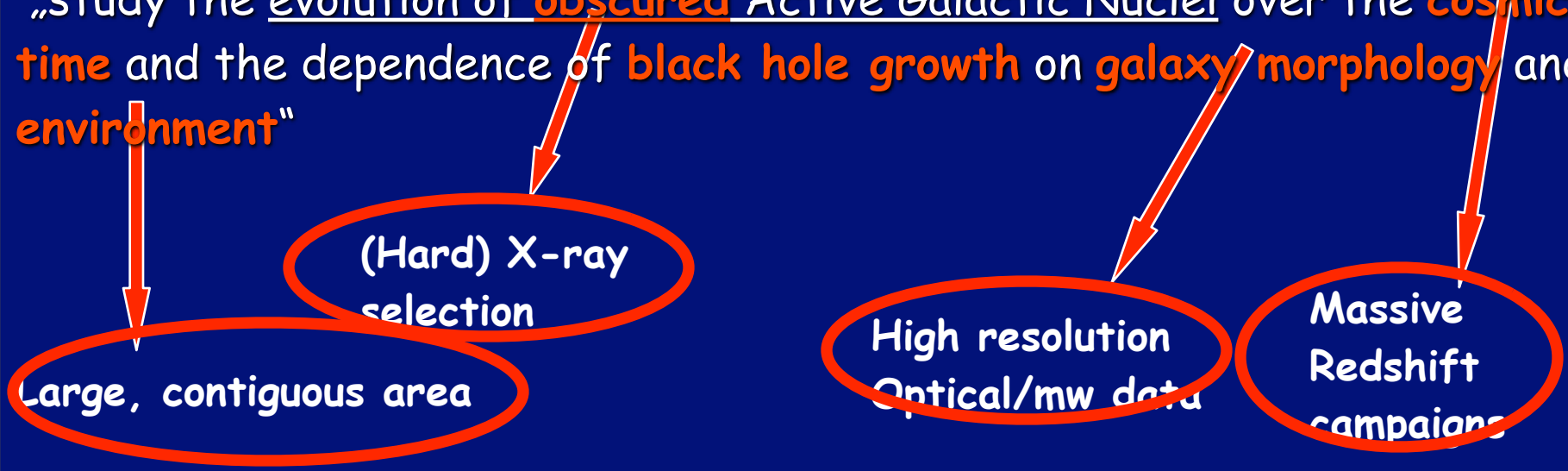
„study the evolution of obscured Active Galactic Nuclei over the cosmic time and the dependence of black hole growth on galaxy morphology and environment"



Motivation of the XMM-COSMOS project

(One of the) Main goal of the XMM-Newton Wide field survey in the COSMOS field is:

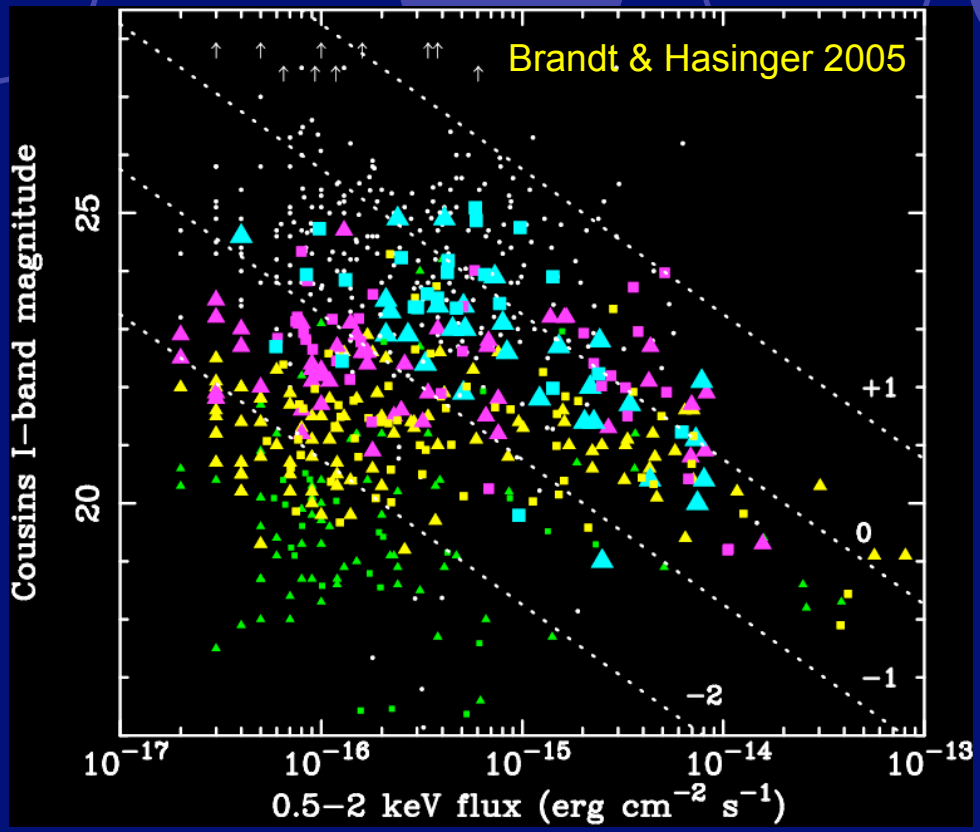
„study the evolution of **obscured** Active Galactic Nuclei over the **cosmic time** and the dependence of **black hole growth** on **galaxy morphology** and **environment**"



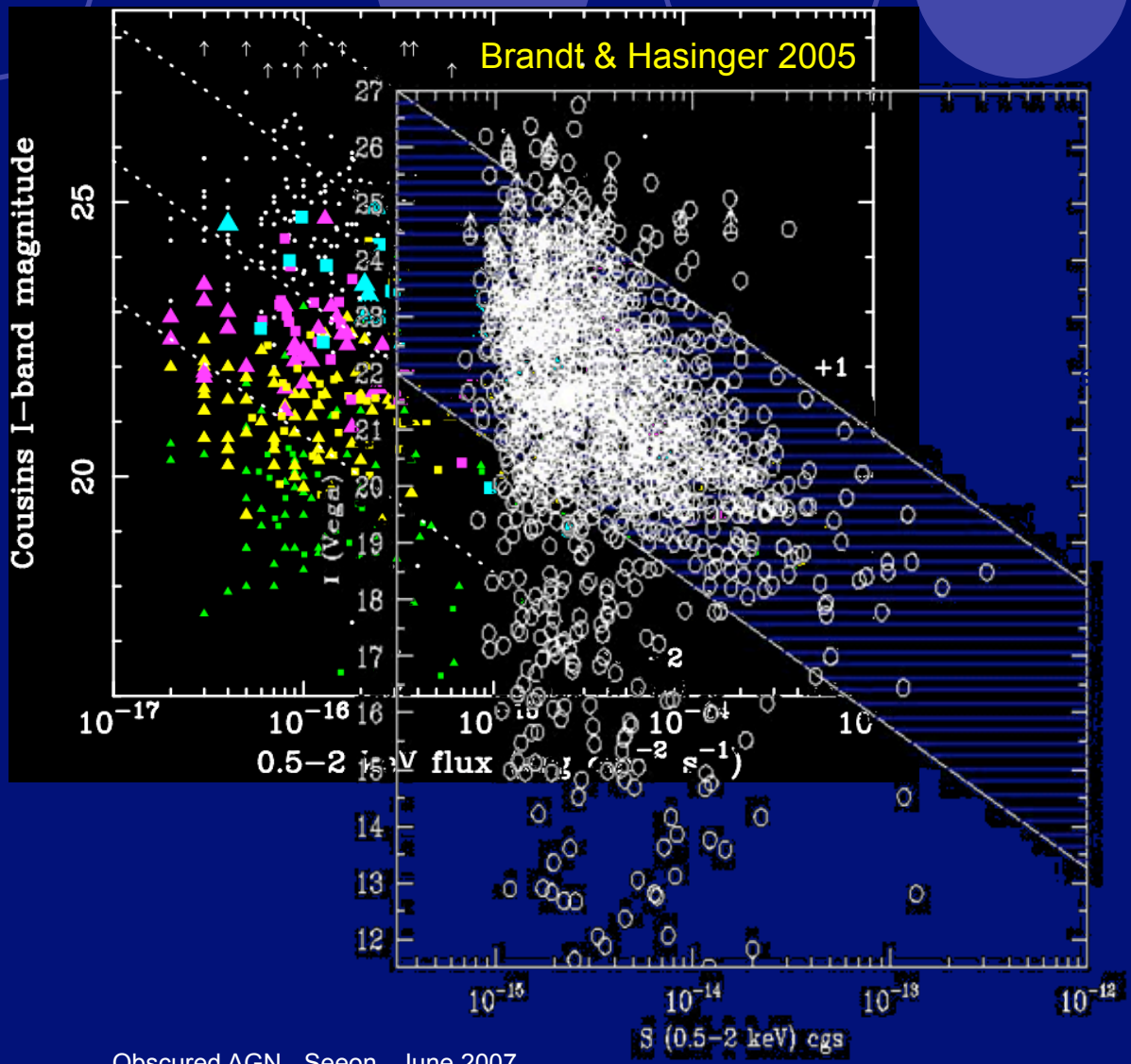
XMM-COSMOS field:

- XMM mosaic, 1865 sources (full sample) / ~1200 sources (3×10^{-15} cgs in 2-10 keV)
  Hasinger et al. 2007, Cappelluti et al. 2007
  http://cosmos.astro.caltech.edu
- 2 deg^2 area
- Complete, deep coverage at all lambda (radio/Spitzer/CFHT/Subaru/ACS/GALEX...)
- Redshifts secured from zCOSMOS/IMACS campaigns (Lilly et al. 2007, Trump et al. 2007)

Identification of AGN in XMM-COSMOS

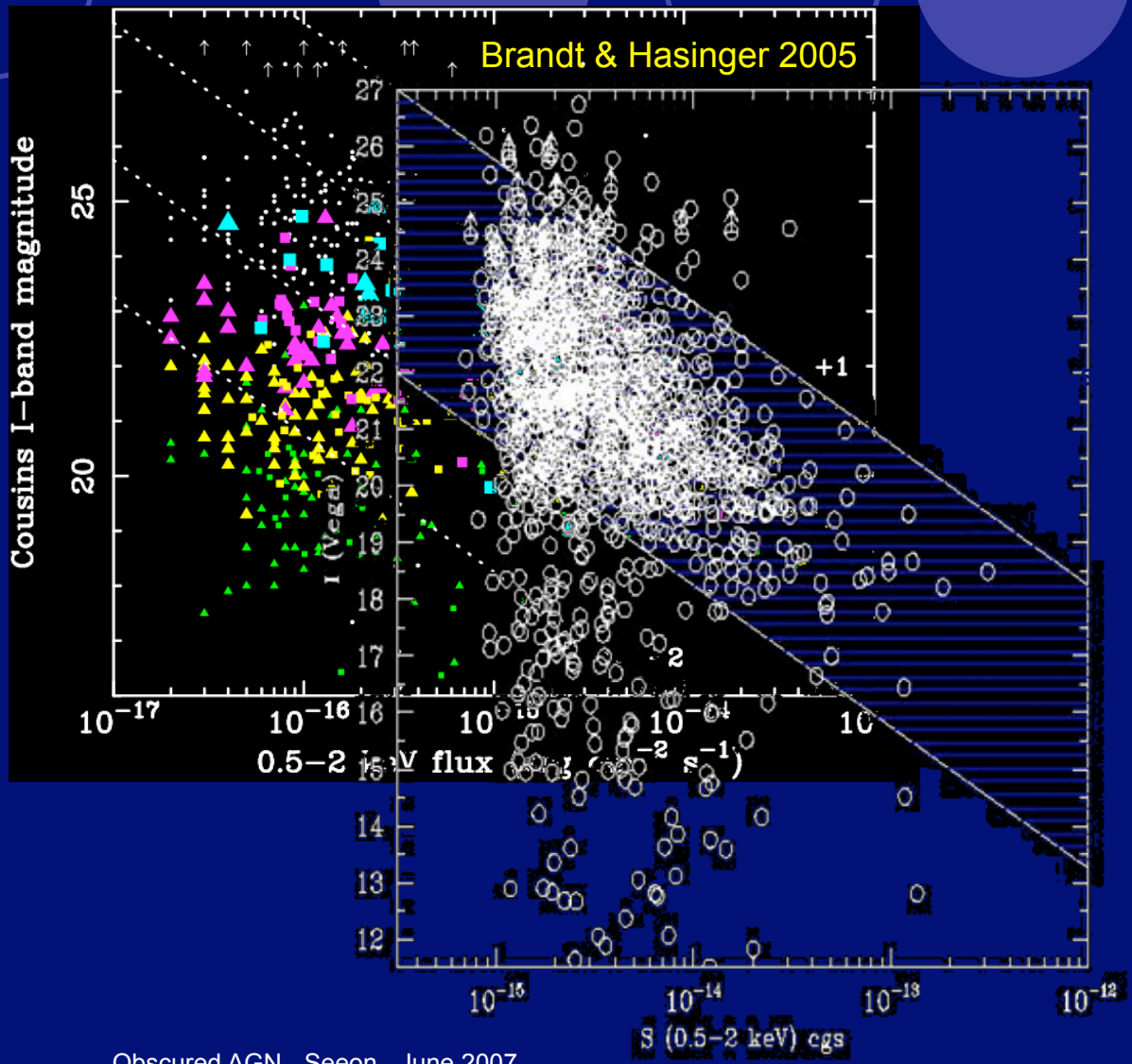


Identification of AGN in XMM-COSMOS



Identification of AGN in XMM-COSMOS

optically faint (I>24) → difficult to identify using optical bands only [see also Alexander et al. 2001, Mignoli et al. 2004, Mainieri et al. 2005 + others] → most interesting sources candidate high-z obscured AGN



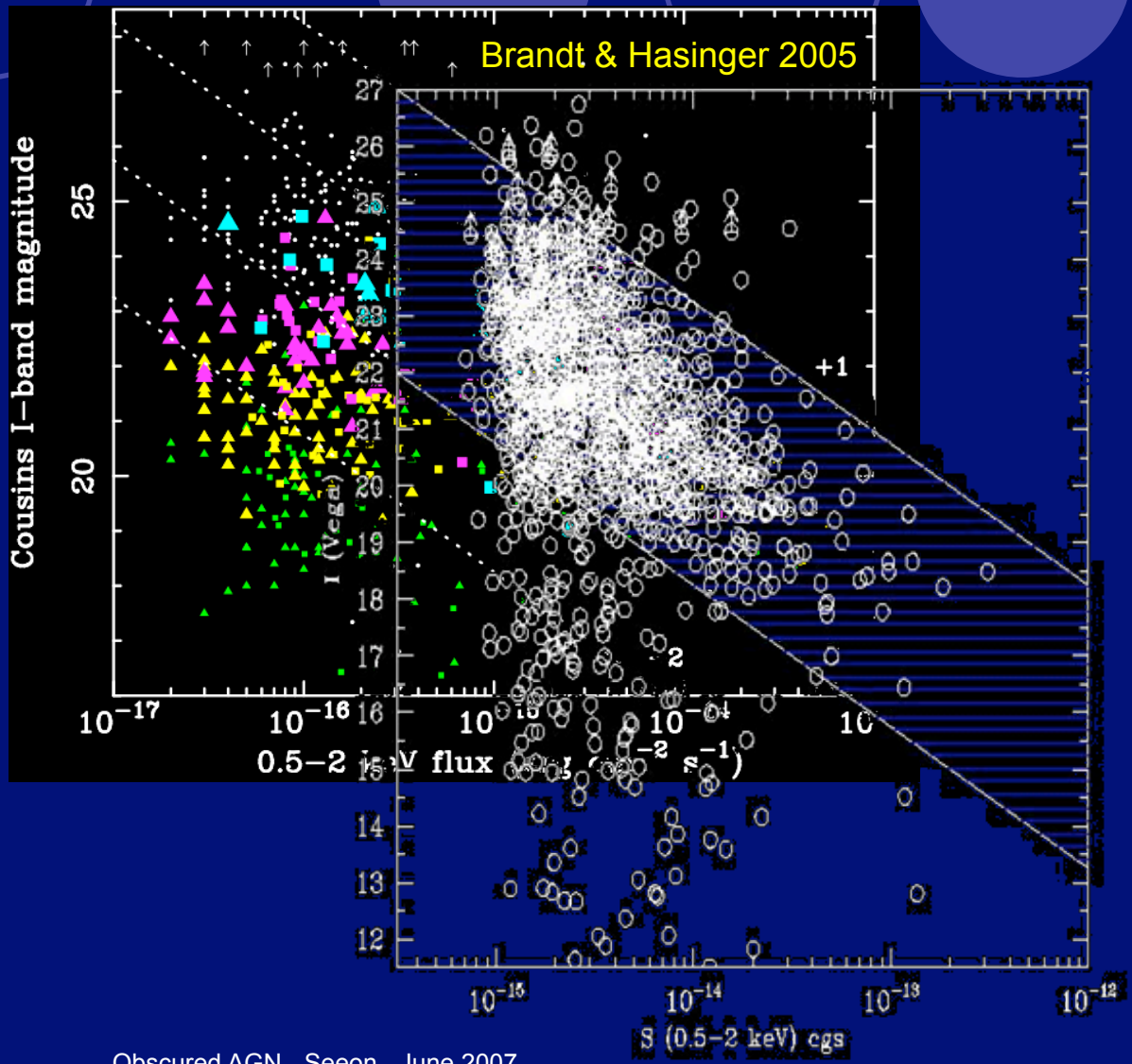
Identification of AGN in XMM-COSMOS

optically faint (I>24) → difficult to identify using optical bands only [see also Alexander et al. 2001, Mignoli et al. 2004, Mainieri et al. 2005 + others] → most interesting sources candidate high-z obscured AGN

(Strong) Help from K-band/IRAC/MIPS data

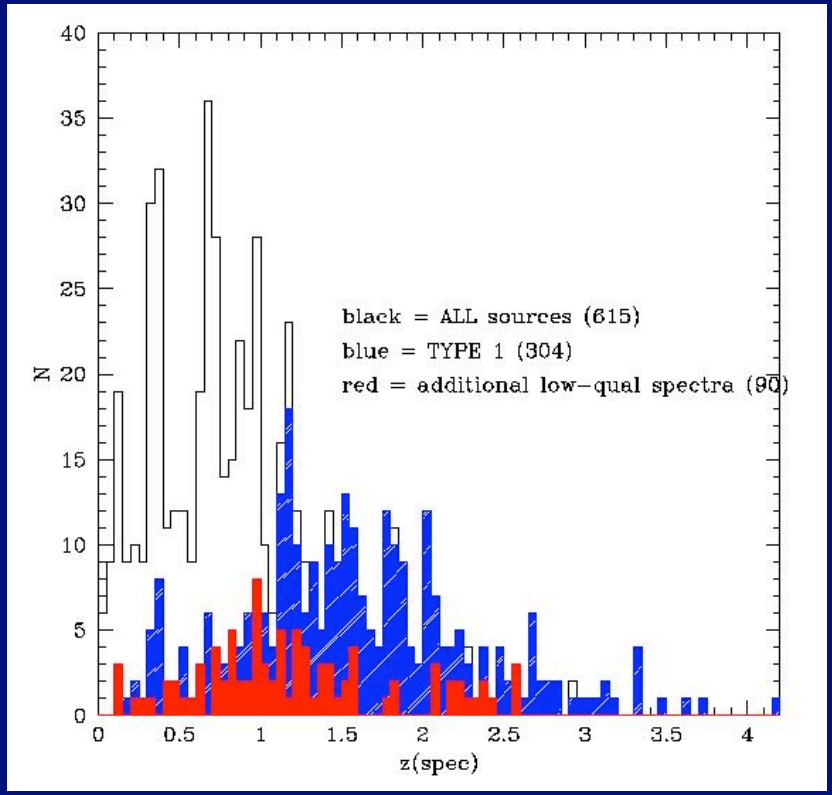
+

control check with Chandra positions



Redshift distribution

compilation from ongoing spectroscopic projects
[IMACS/zCOSMOS + SDSS + literature data]

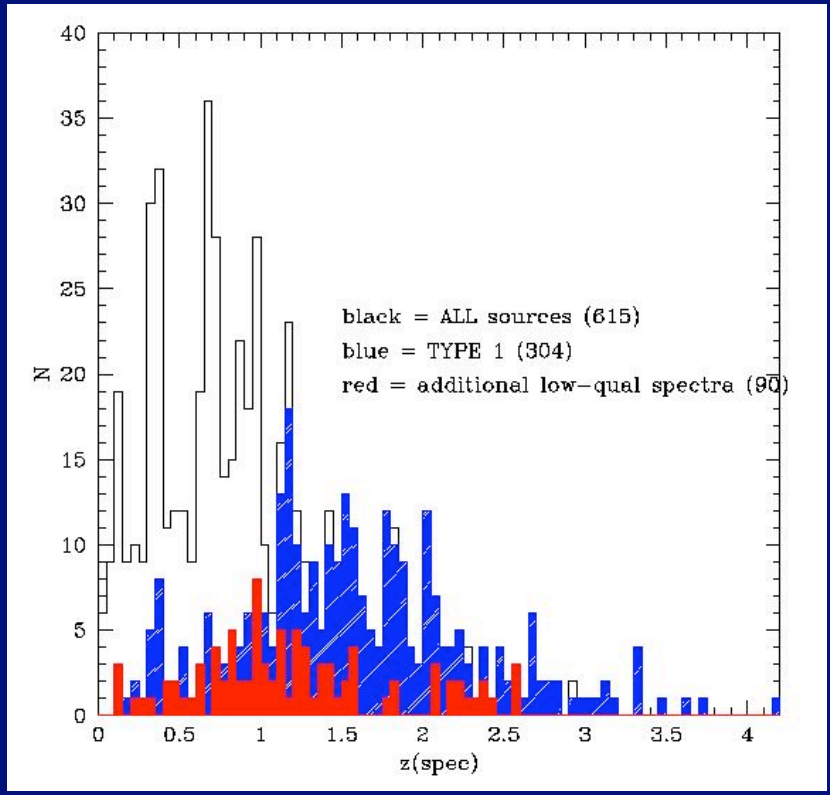


(adapted from Brusa et al. 2007 ApJS)

Redshift distribution

compilation from ongoing spectroscopic projects
[IMACS/zCOSMOS + SDSS + literature data]

- ~650 "secure" spectroscopic identifications



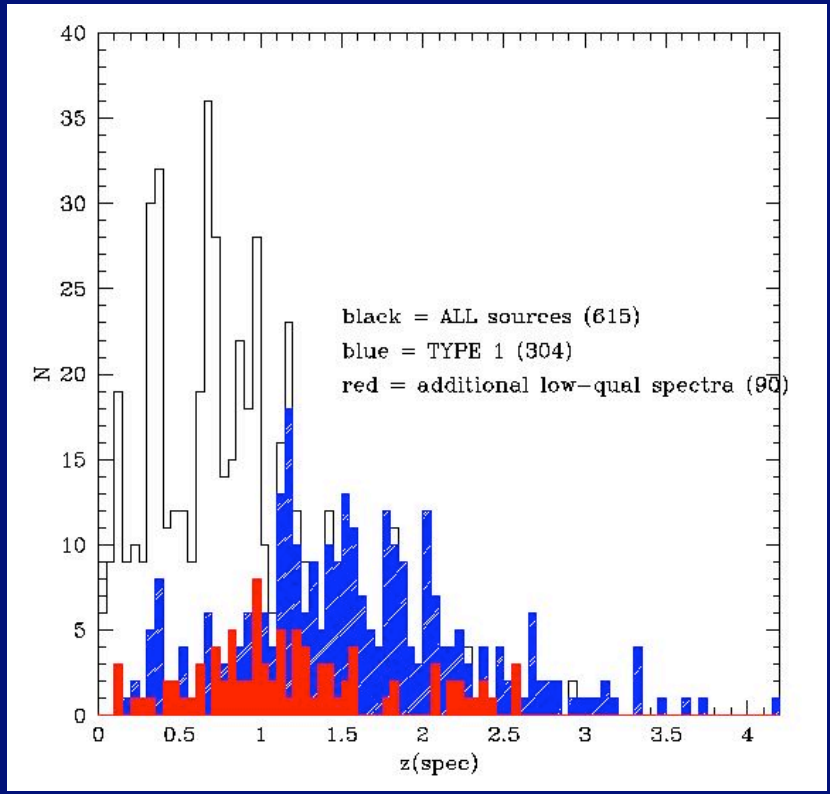
(adapted from Brusa et al. 2007 ApJS)

Redshift distribution

compilation from ongoing spectroscopic projects
[IMACS/zCOSMOS + SDSS + literature data]

- ~650 "secure" spectroscopic identifications

  [35% of the full sample, almost 50% completeness in the I<22 sample]



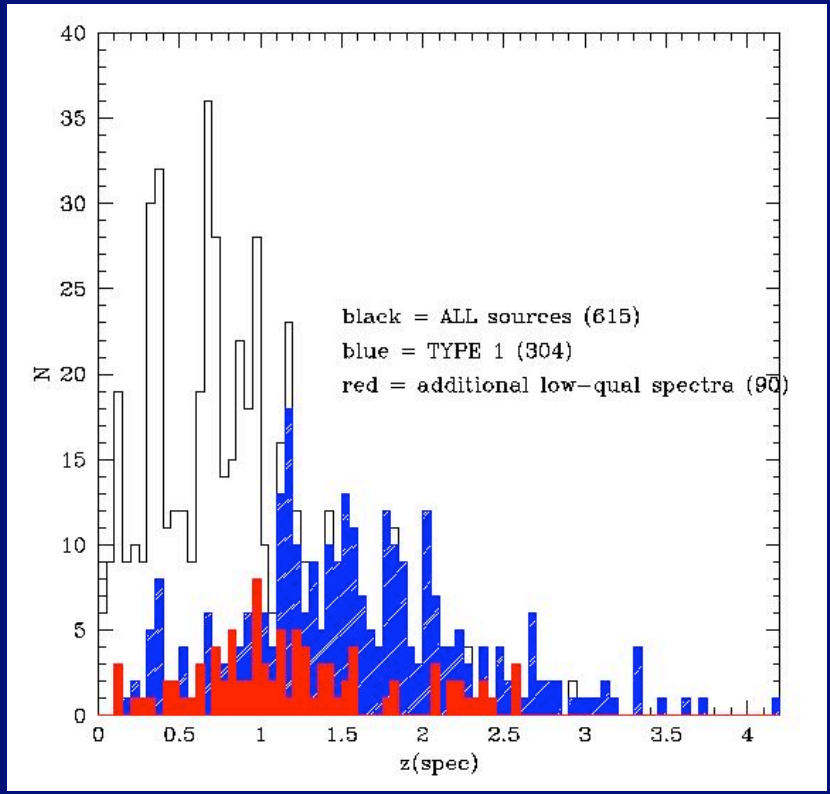
(adapted from Brusa et al. 2007 ApJS)

Redshift distribution

compilation from ongoing spectroscopic projects
[IMACS/zCOSMOS + SDSS + literature data]

- ~650 "secure" spectroscopic identifications

  [35% of the full sample, almost 50% completeness in the I<22 sample]



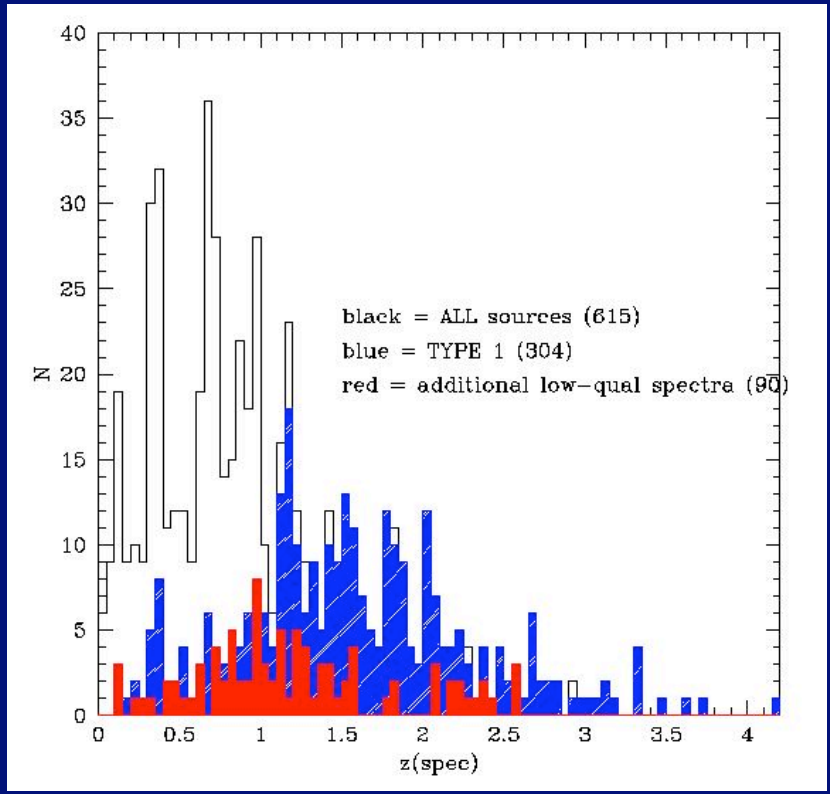
(adapted from Brusa et al. 2007 ApJS)

Redshift distribution

compilation from ongoing spectroscopic projects
[IMACS/zCOSMOS + SDSS + literature data]

- ~650 "secure" spectroscopic identifications

  [35% of the full sample, almost 50% completeness in the I<22 sample]



(adapted from Brusa et al. 2007 ApJS)

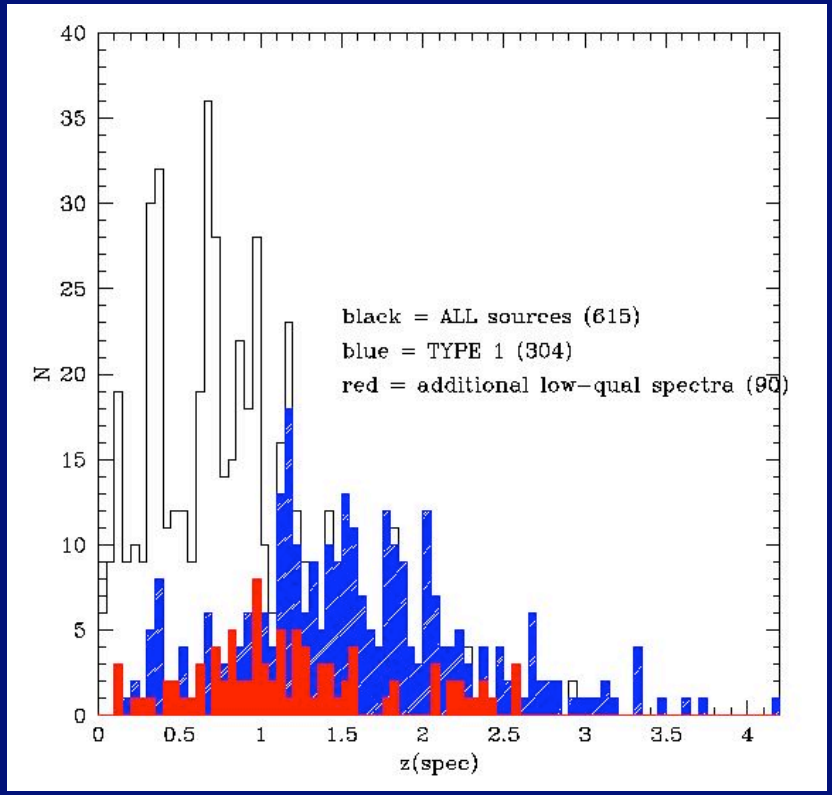
Redshift distribution

compilation from ongoing spectroscopic projects
[IMACS/zCOSMOS + SDSS + literature data]

- ~650 "secure" spectroscopic identifications

  [35% of the full sample, almost 50% completeness in the I<22 sample]

- BL AGNs dominate at z>1



(adapted from Brusa et al. 2007 ApJS)

Redshift distribution

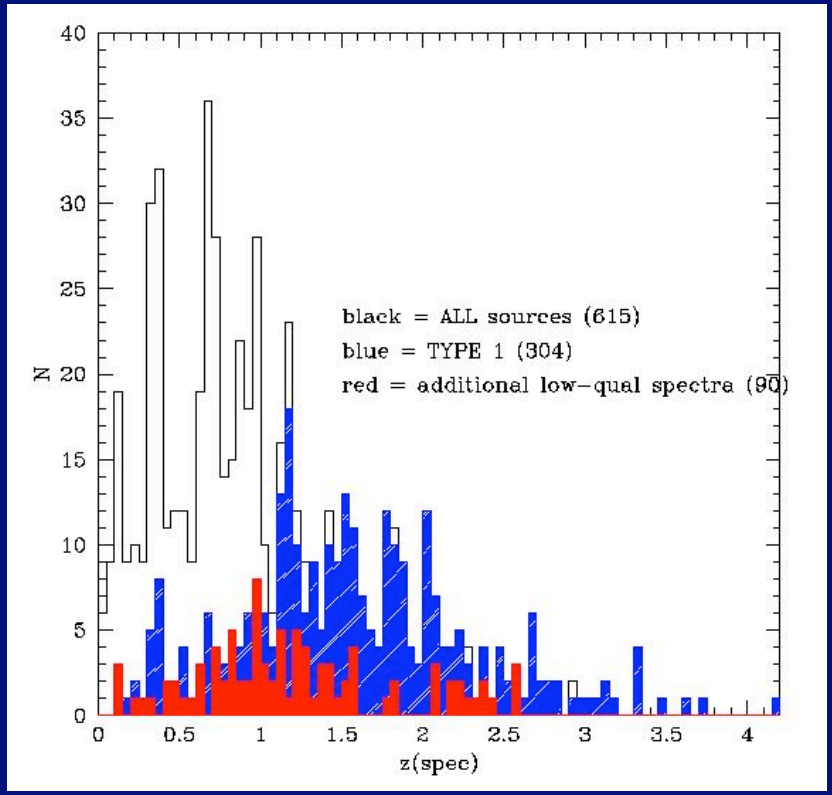
compilation from ongoing spectroscopic projects
[IMACS/zCOSMOS + SDSS + literature data]

- ~650 "secure" spectroscopic identifications

  [35% of the full sample, almost 50% completeness in the I<22 sample]

- BL AGNs dominate at z>1

  → High redshift type 2 objects missing (partly selection effect)



(adapted from Brusa et al. 2007 ApJS)

Redshift distribution

compilation from ongoing spectroscopic projects
[IMACS/zCOSMOS + SDSS + literature data]

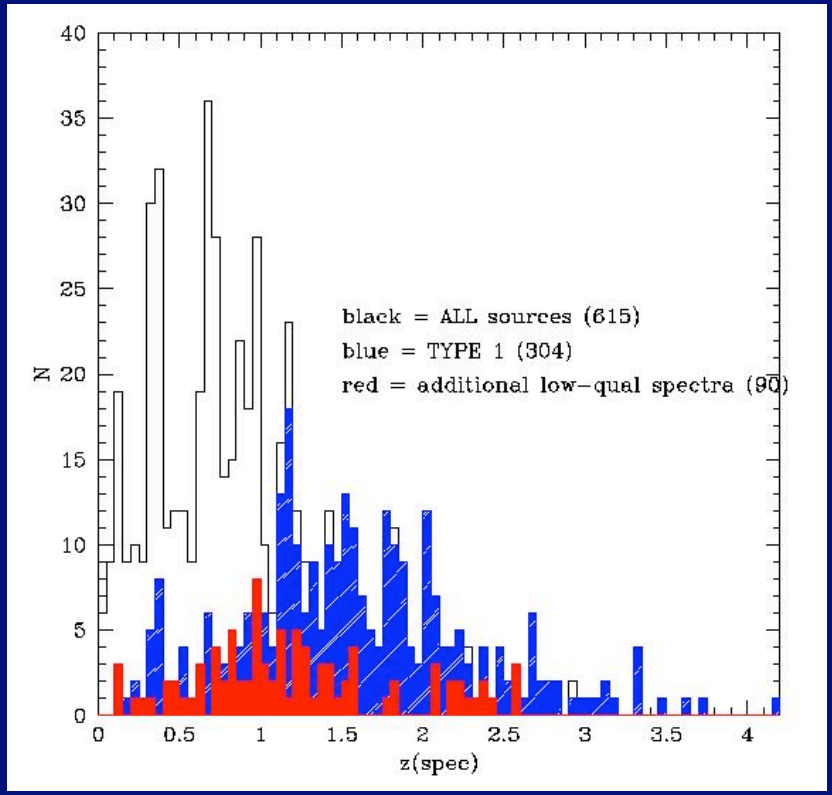
- ~650 "secure" spectroscopic identifications

  [35% of the full sample, almost 50% completeness in the I<22 sample]

- BL AGNs dominate at z>1

  → High redshift type 2 objects missing (partly selection effect)

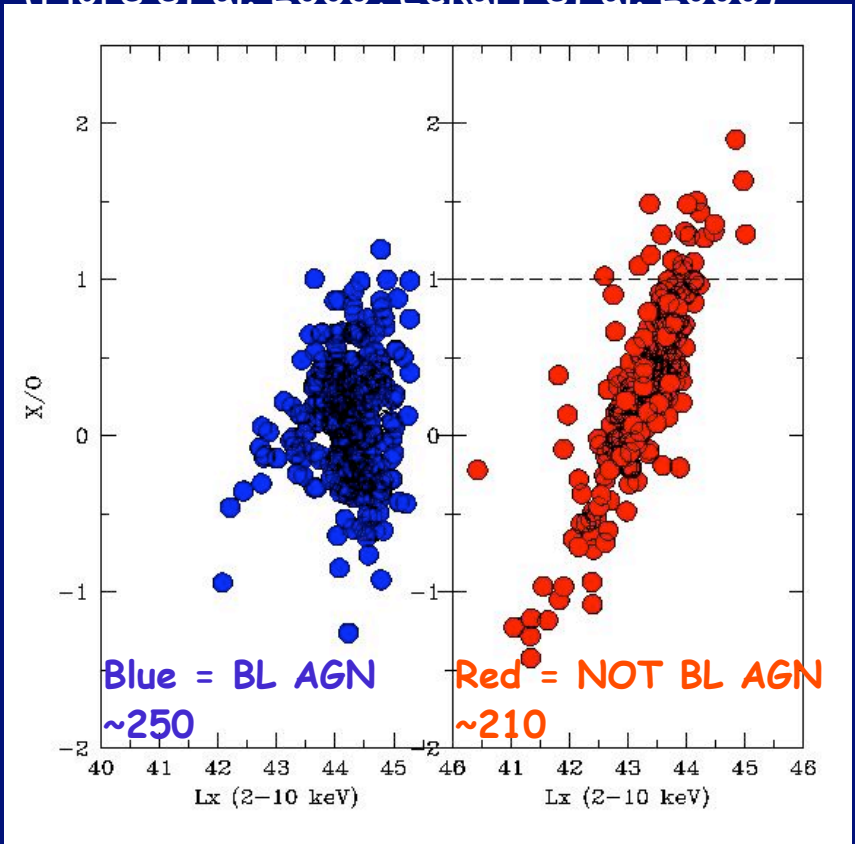
[see also results from HELLAS2XMM, Cocchia et al. 2007 and from the SEXSI survey, Eckart et al. 2006]



(adapted from Brusa et al. 2007 ApJS)

How to isolate most luminous, obscured sources in XMM-COSMOS (1)?

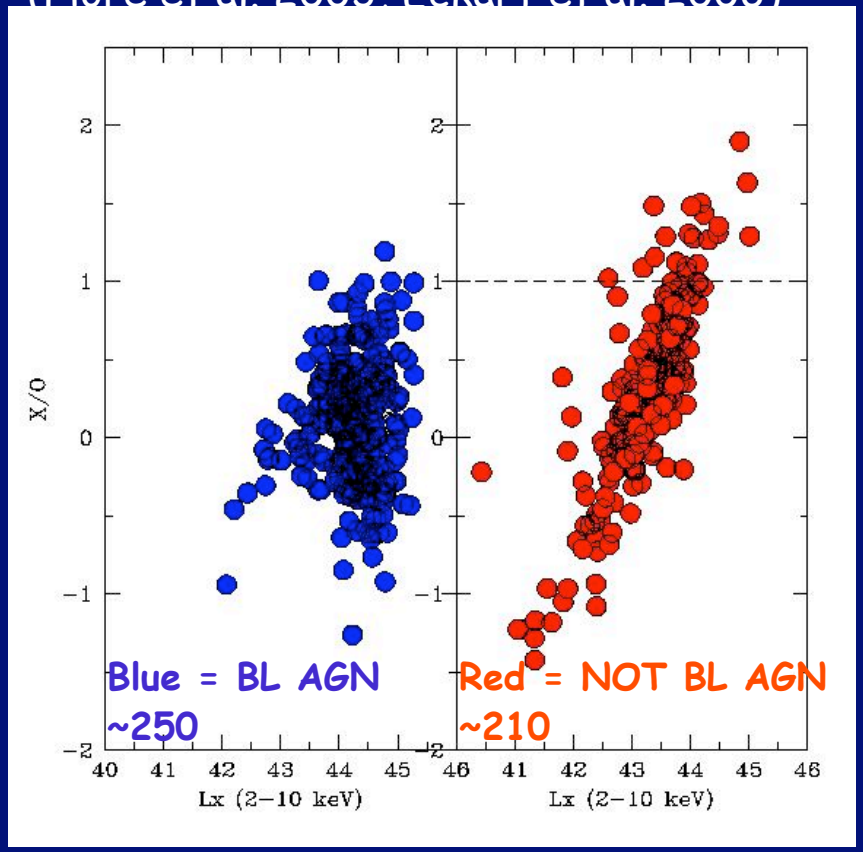
High X/O ratio is a proxy for high L
(Fiore et al. 2003, Eckart et al. 2006)



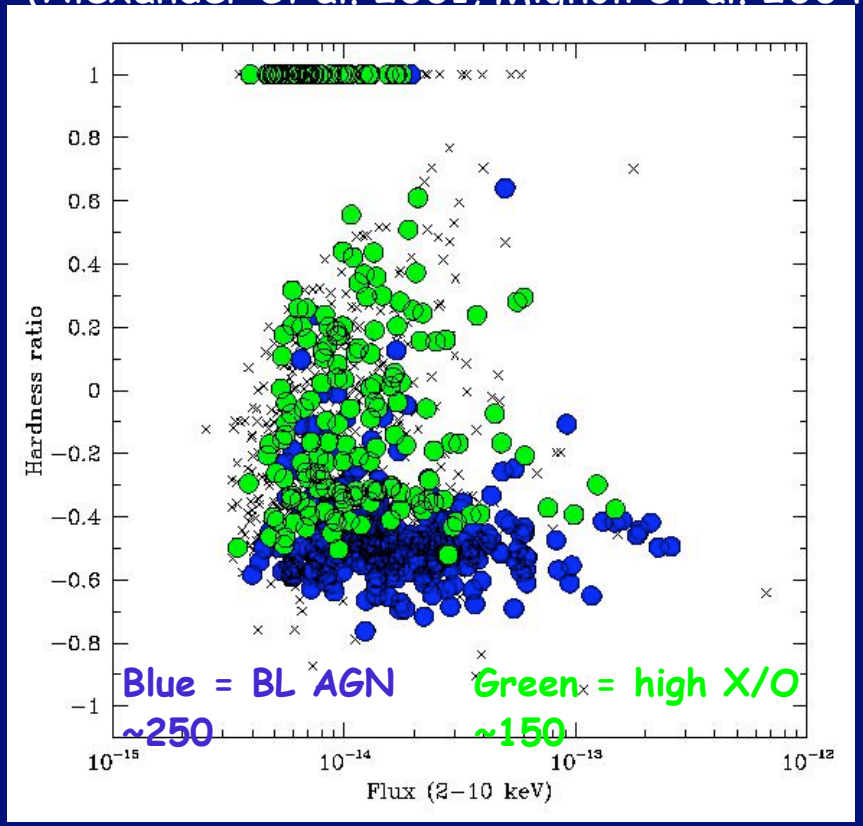
X/O = Hard X-ray to optical flux ratio

How to isolate most luminous, obscured sources in XMM-COSMOS (1)?

High X/O ratio is a proxy for high L
(Fiore et al. 2003, Eckart et al. 2006)



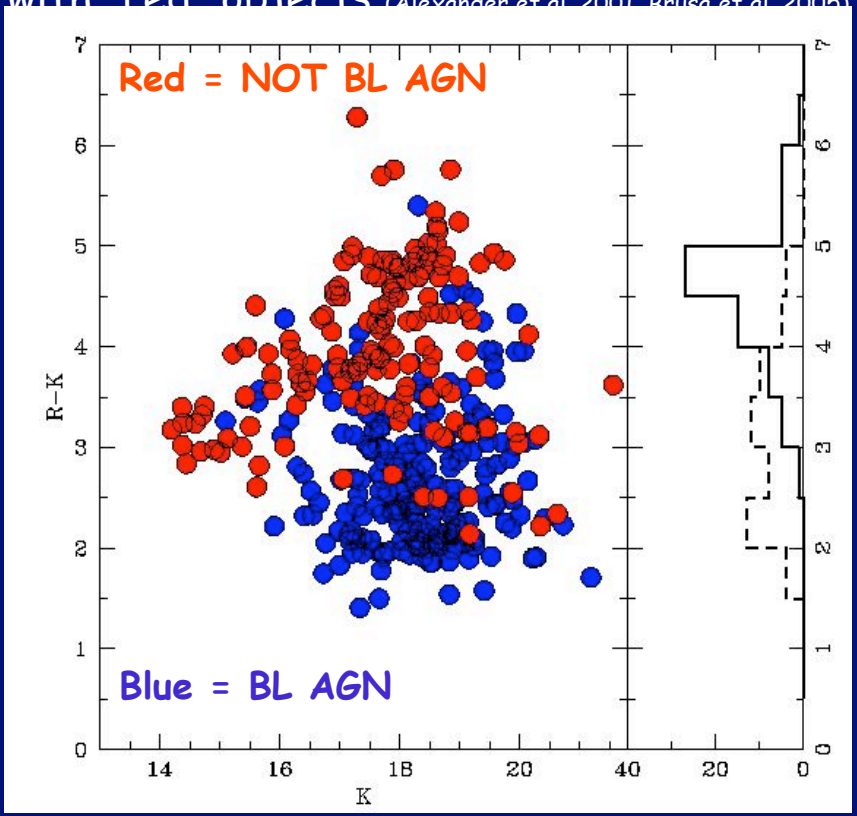
High X/O sources are harder than BL AGN
(Alexander et al. 2001, Mignoli et al. 2004)



X/O = Hard X-ray to optical flux ratio

How to isolate most luminous, obscured sources in XMM-COSMOS (2)?

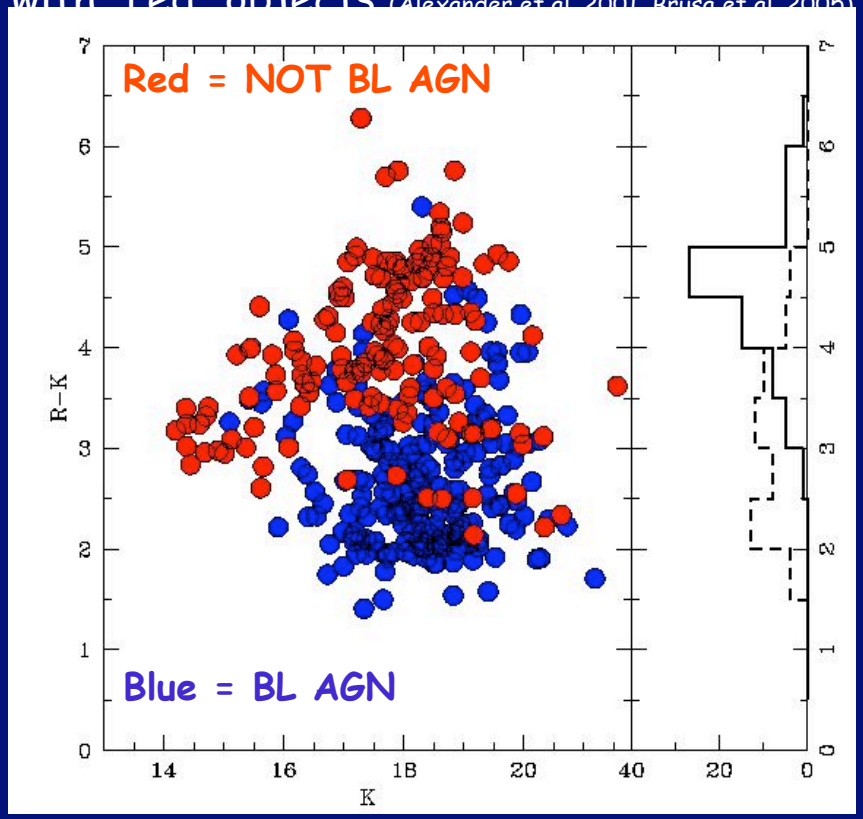
Obscured sources (**NOT BL AGN** and hard sources) are preferentially associated with "red" objects (Alexander et al. 2001, Brusa et al. 2005)



Brusa et al. 2007, Mainieri et al. 2007

How to isolate most luminous, obscured sources in XMM-COSMOS (2)?

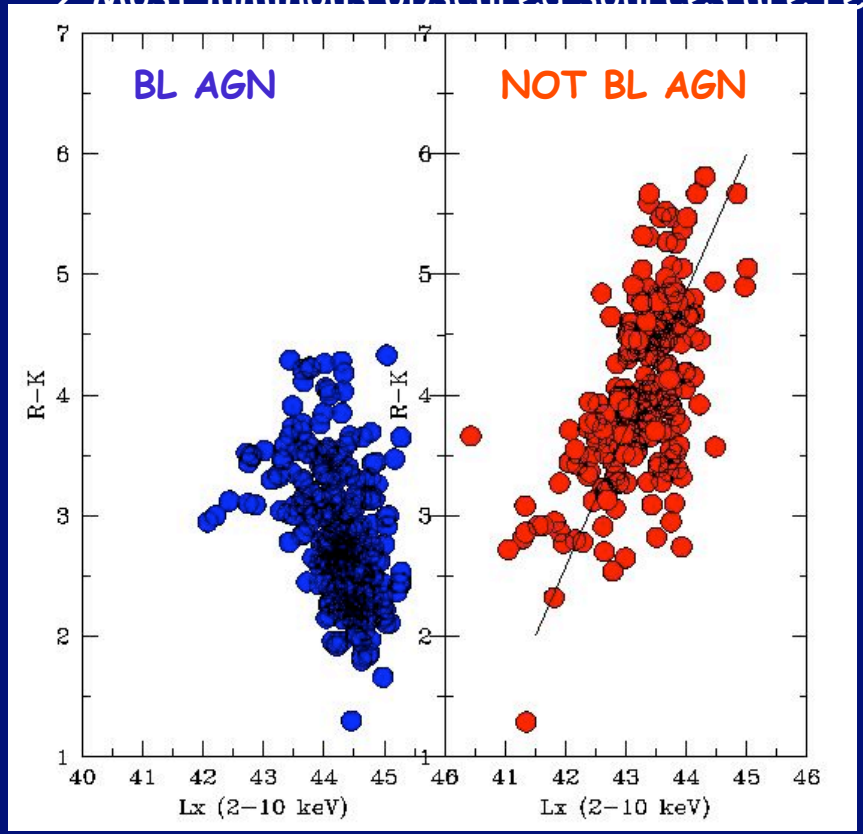
Obscured sources (**NOT BL AGN** and hard sources) are preferentially associated with "red" objects (Alexander et al. 2001, Brusa et al. 2005)



For obscured sources:

R-K correlates with (observed) Lx

→ Most luminous obscured sources are red!

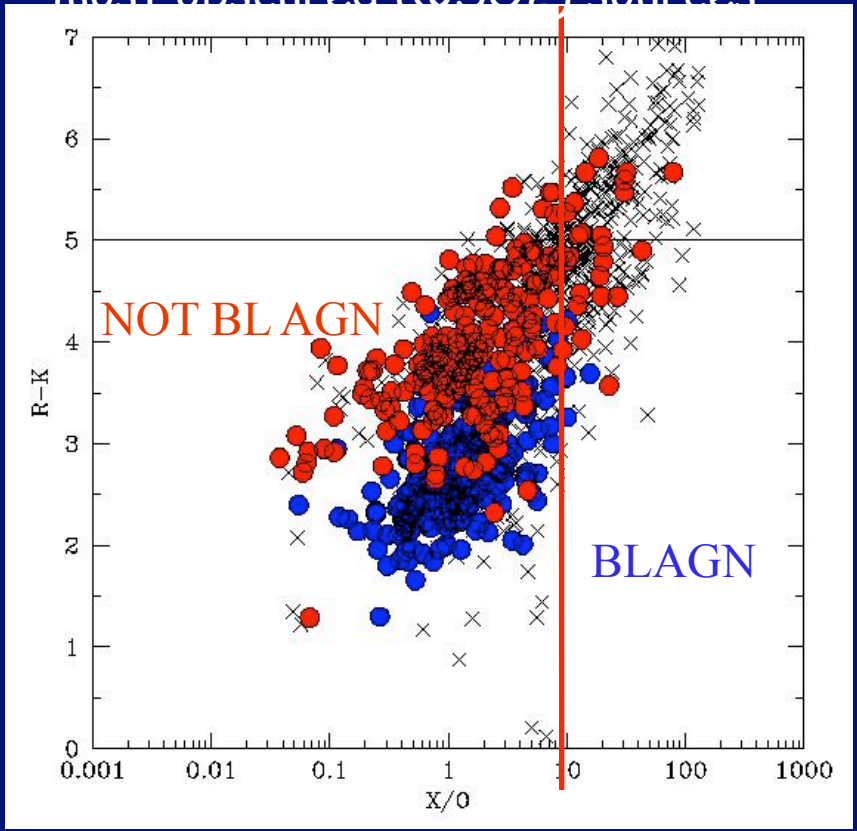


Brusa et al. 2007, Mainieri et al. 2007

combining R-K and X/O

X/O correlates with R-K

→combine these 2 criteria to isolate most obscured (QSO2) sources

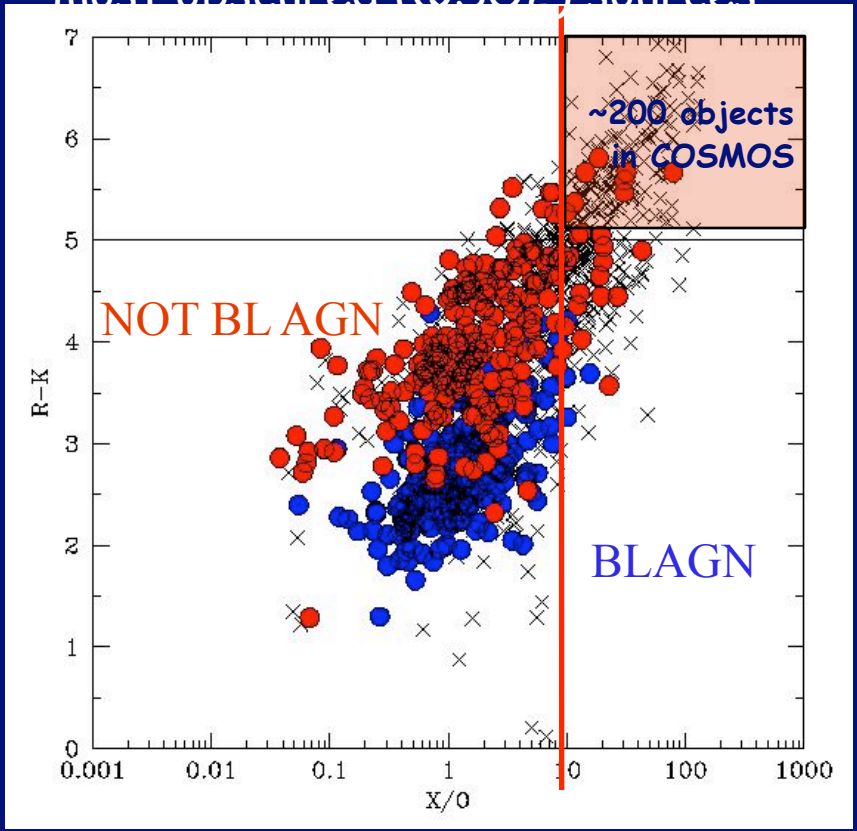


Civano et al. in preparation, see also Brusa et al. 2005 Severgnini et al. 2005, Maiolino et al. 2006

combining R-K and X/O

X/O correlates with R-K

→combine these 2 criteria to isolate most obscured (QSO2) sources

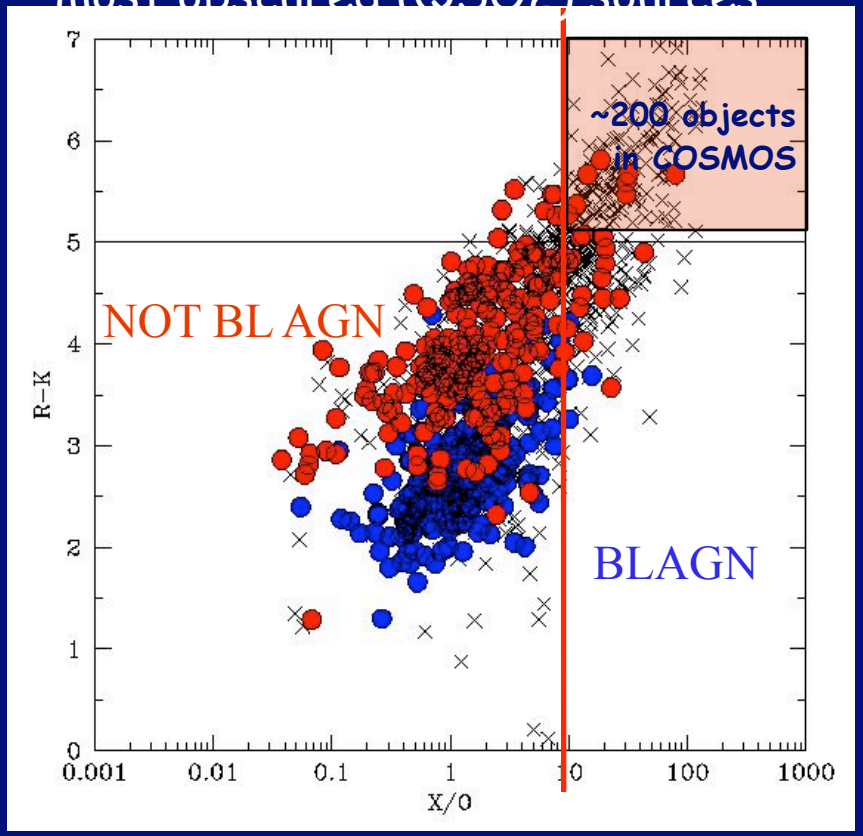


Civano et al. in preparation, see also Brusa et al. 2005 Severgnini et al. 2005, Maiolino et al. 2006

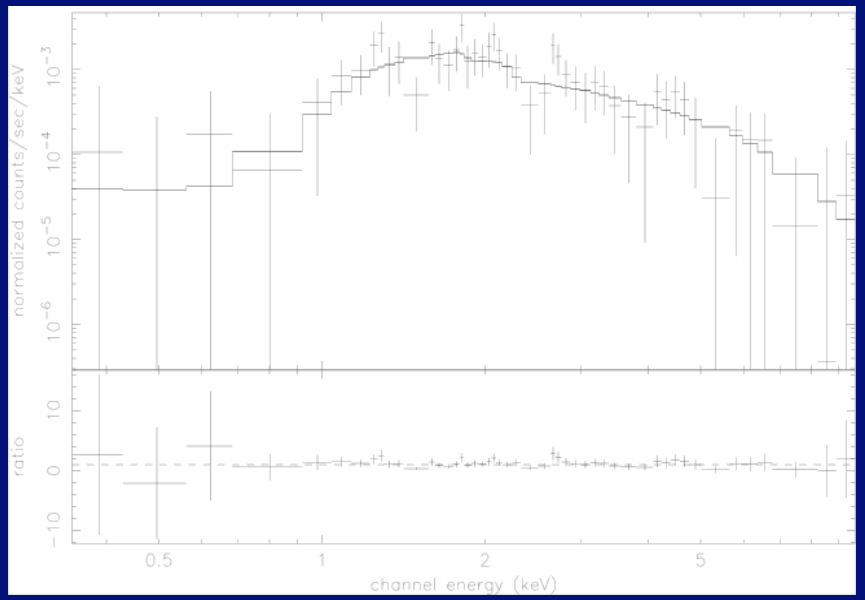
combining R-K and X/O

X/O correlates with R-K

→combine these 2 criteria to isolate most obscured (QSO2) sources



Civano et al. in preparation, see also Brusa et al. 2005 Severgnini et al. 2005, Maiolino et al. 2006



Mainieri et al. 2007

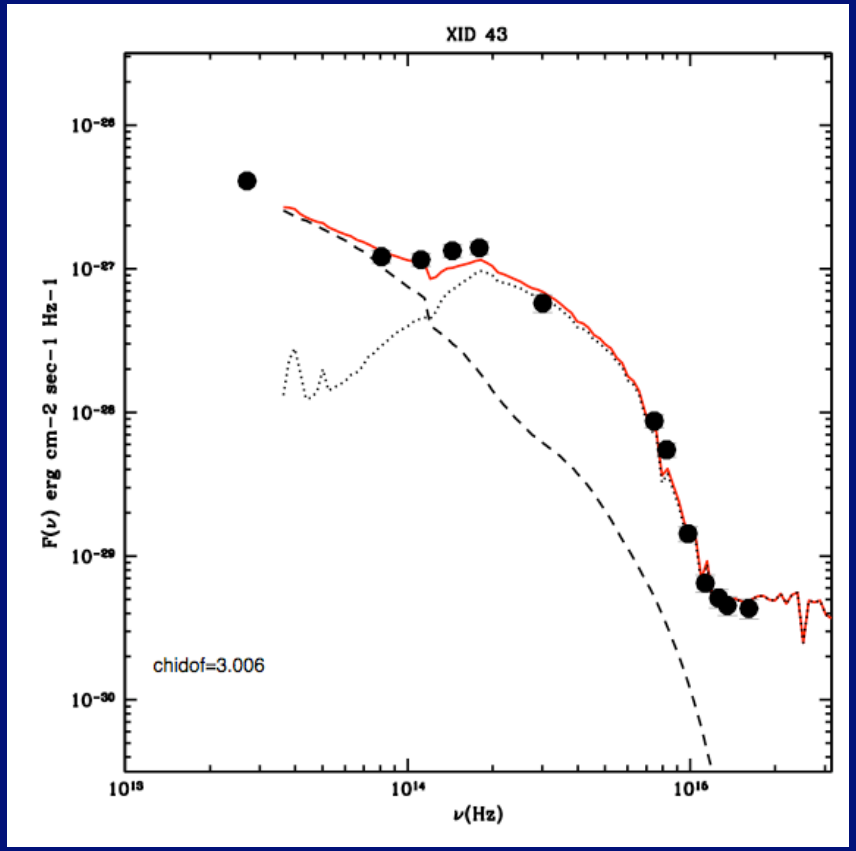
QSO2:

$N_H \sim 10^{23}$ cm^{-2}

$L_{2\text{-}10\ keV} = 5 \times 10^{44}$ erg/s

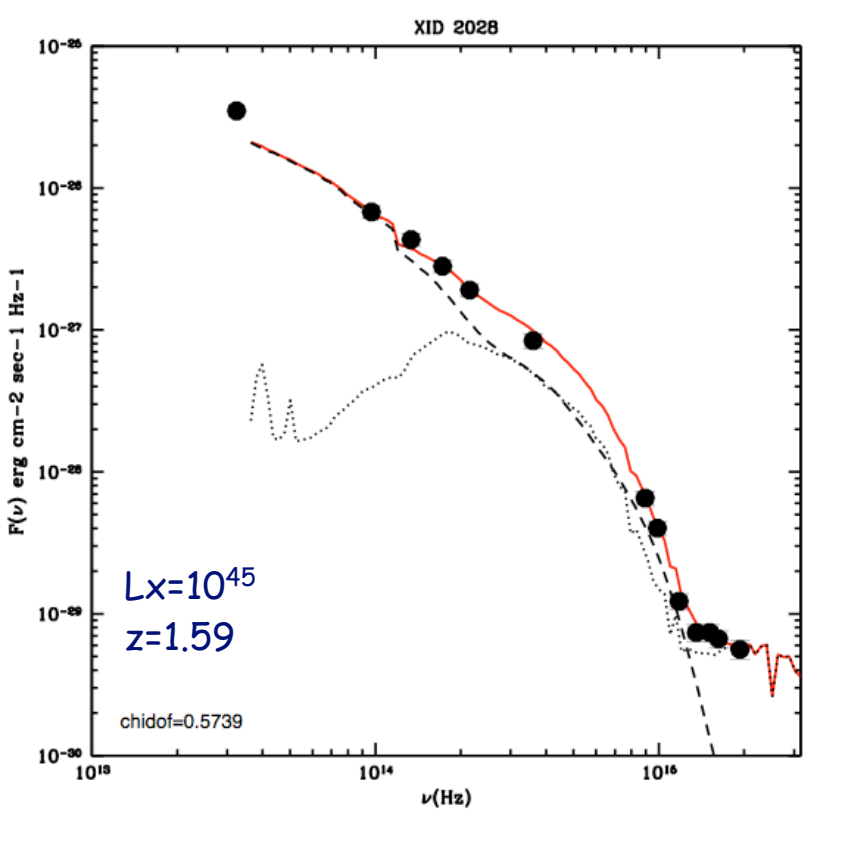
z(phot)=1.2

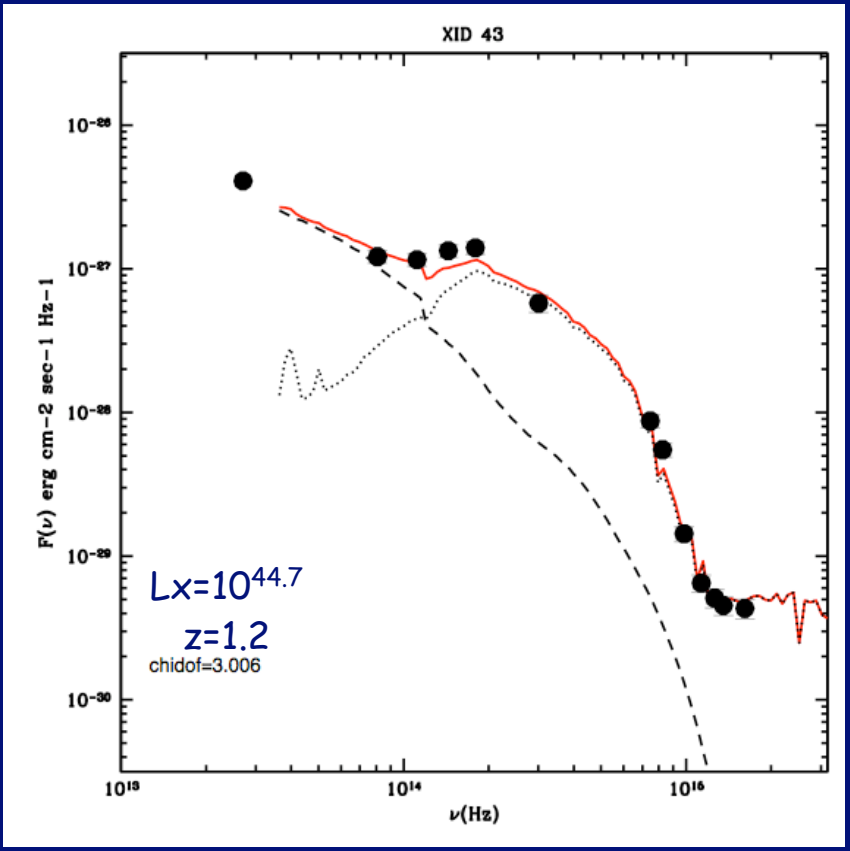
SED fitting: AGN or host galaxyy?



SED fitting: AGN or host galaxyy?

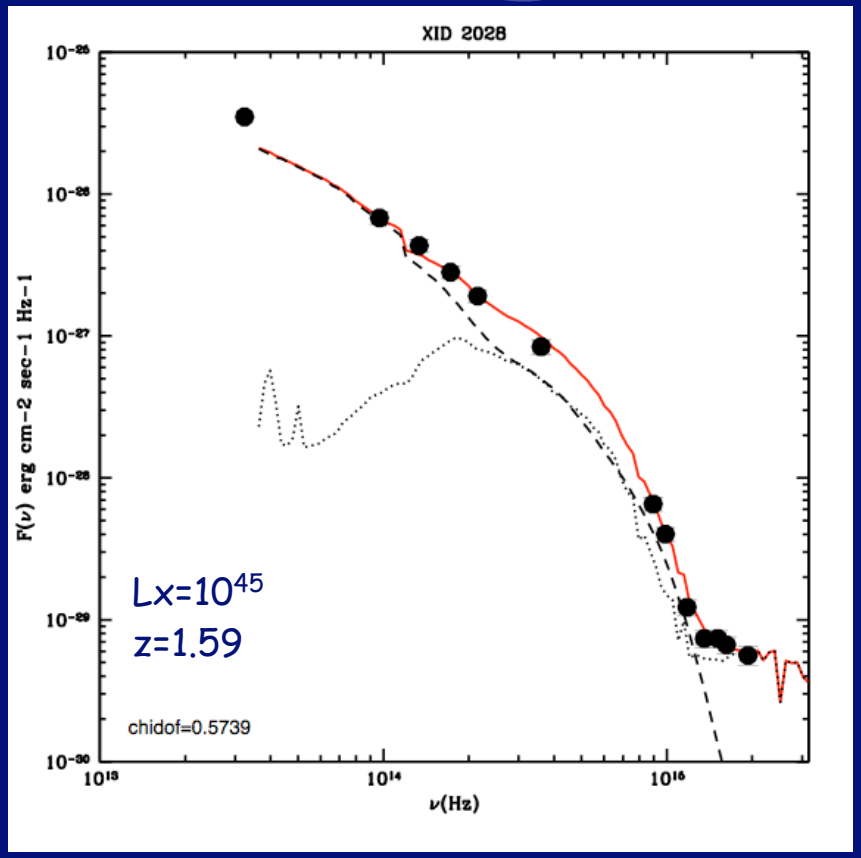
(Civano et al. in preparation; see also results from H2XMM - Pozzi et al. 2007)

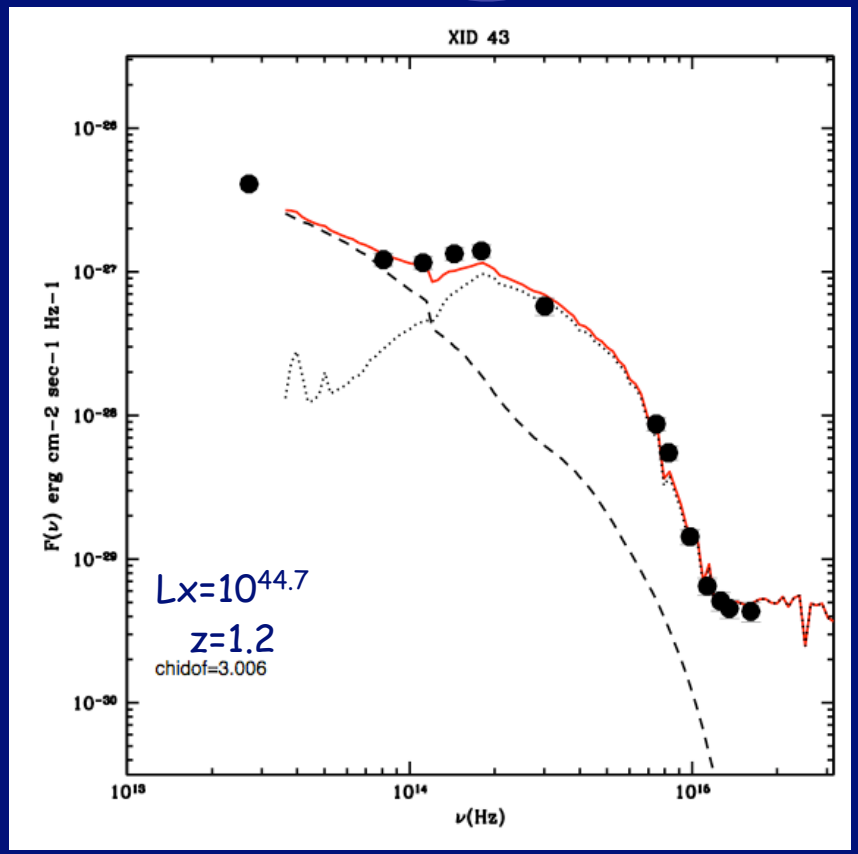




SED fitting: AGN or host galaxyy?

(Civano et al. in preparation; see also results from H2XMM - Pozzi et al. 2007)

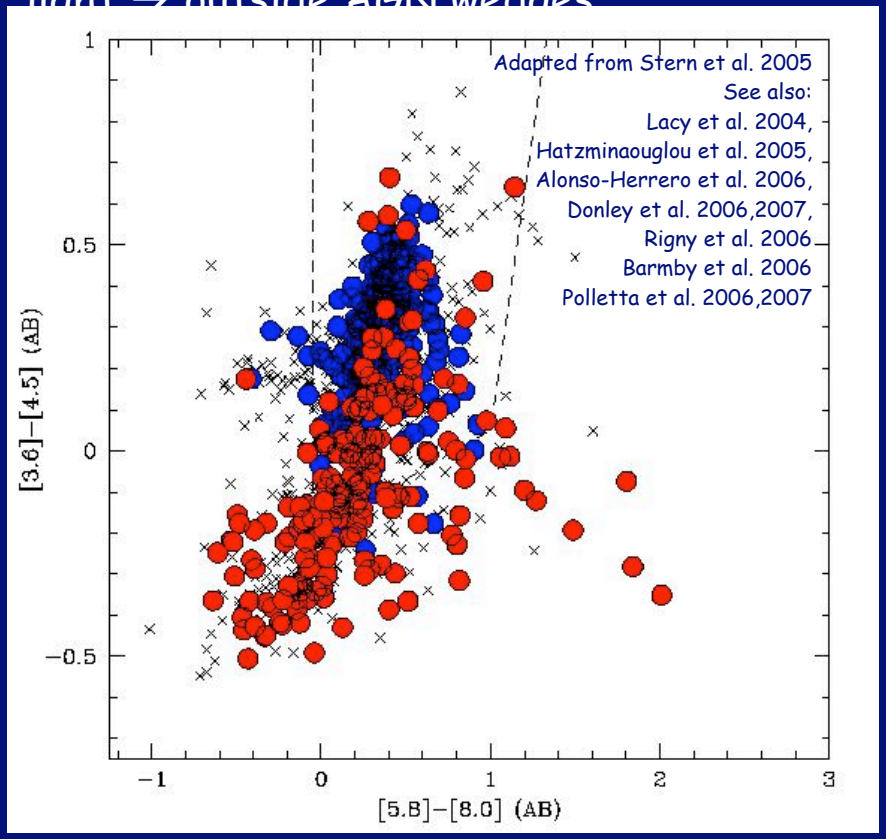




→Different behaviour at longer wavelength

IRAC color-color diagram

IRAC colours of **NOT BL AGN** (RED) show significant contribution from host galaxy light → outside AGN wedges

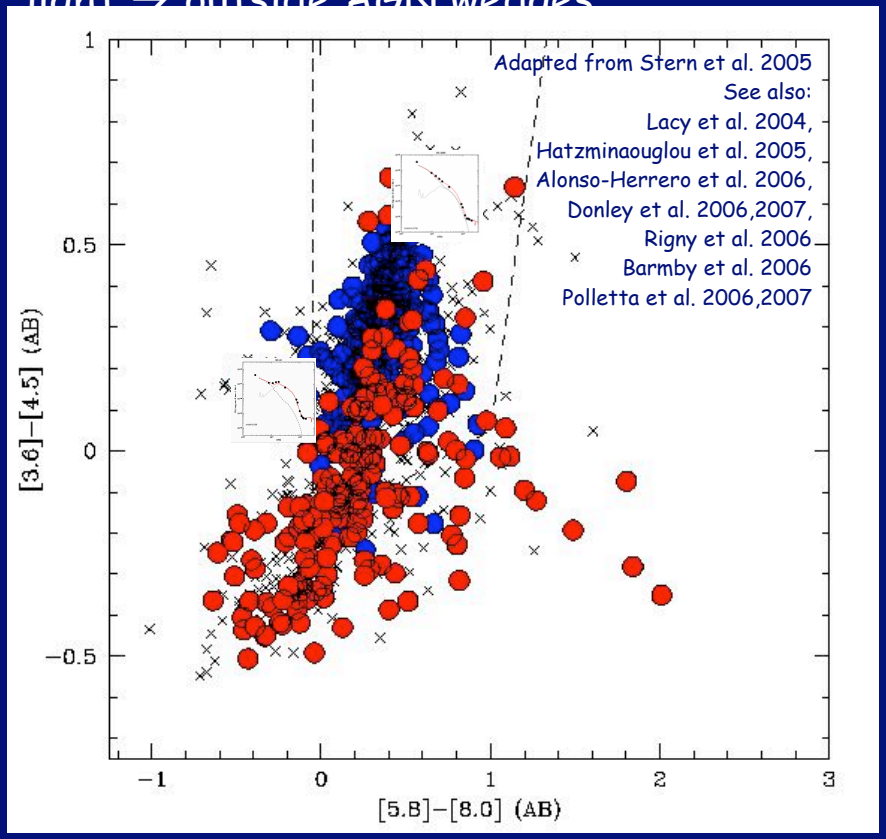


Filled: Lx>43.5

Open: Lx<43.5

IRAC color-color diagram

IRAC colours of **NOT BL AGN** (RED) show significant contribution from host galaxy light → outside AGN wedges

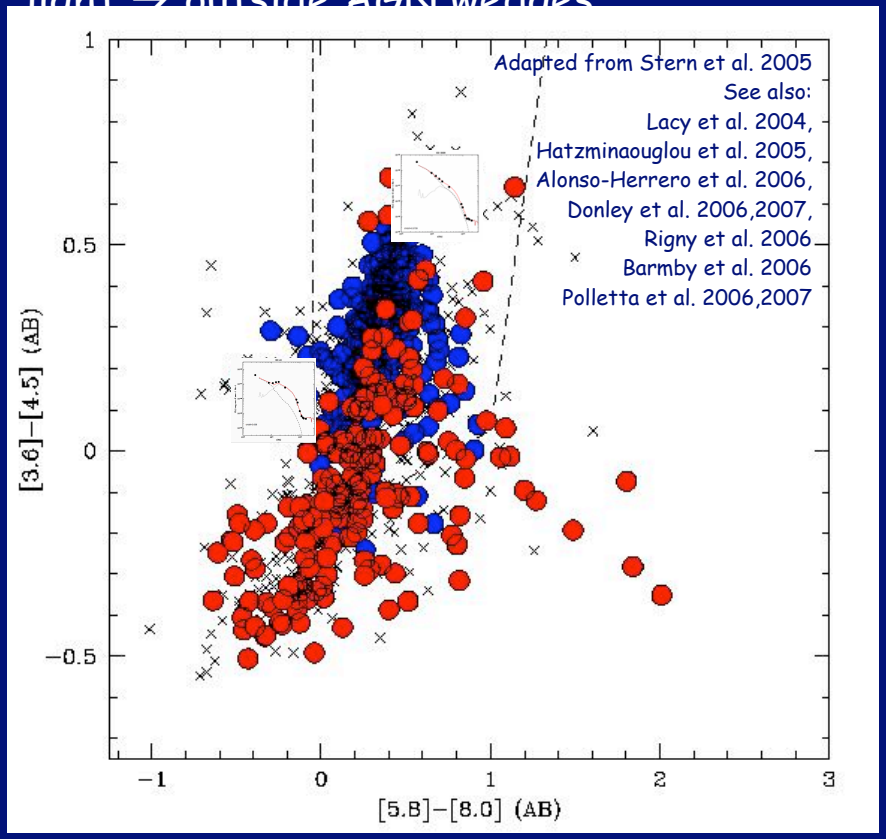


Filled: Lx>43.5

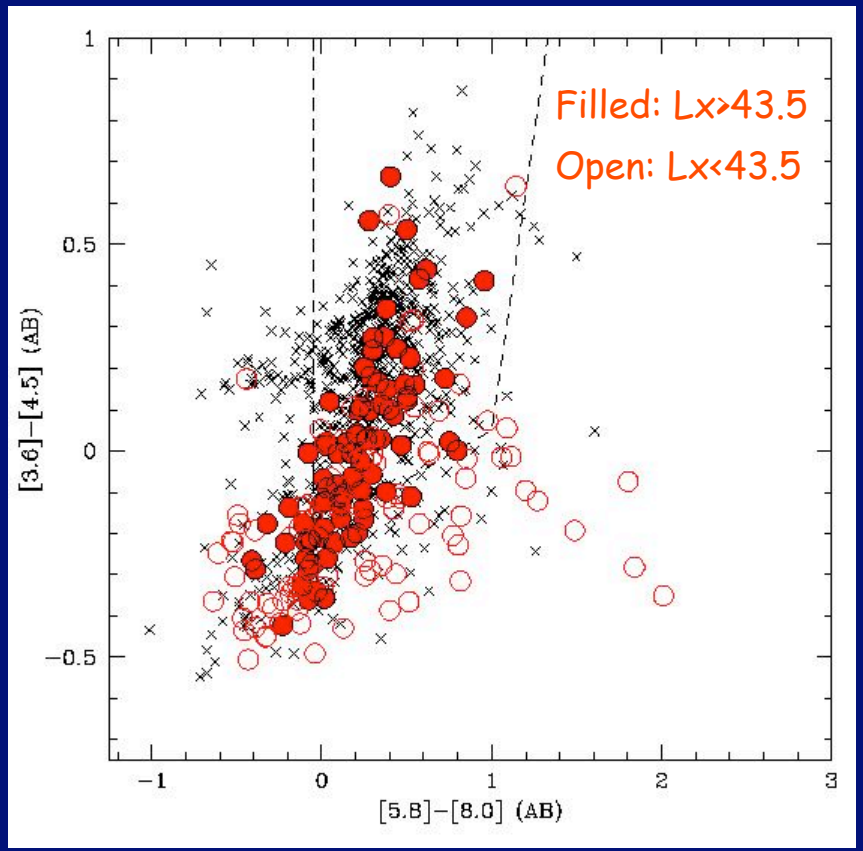
Open: Lx<43.5

IRAC color-color diagram

IRAC colours of **NOT BL AGN** (RED) show significant contribution from host galaxy light ⇒ outside AGN wedges

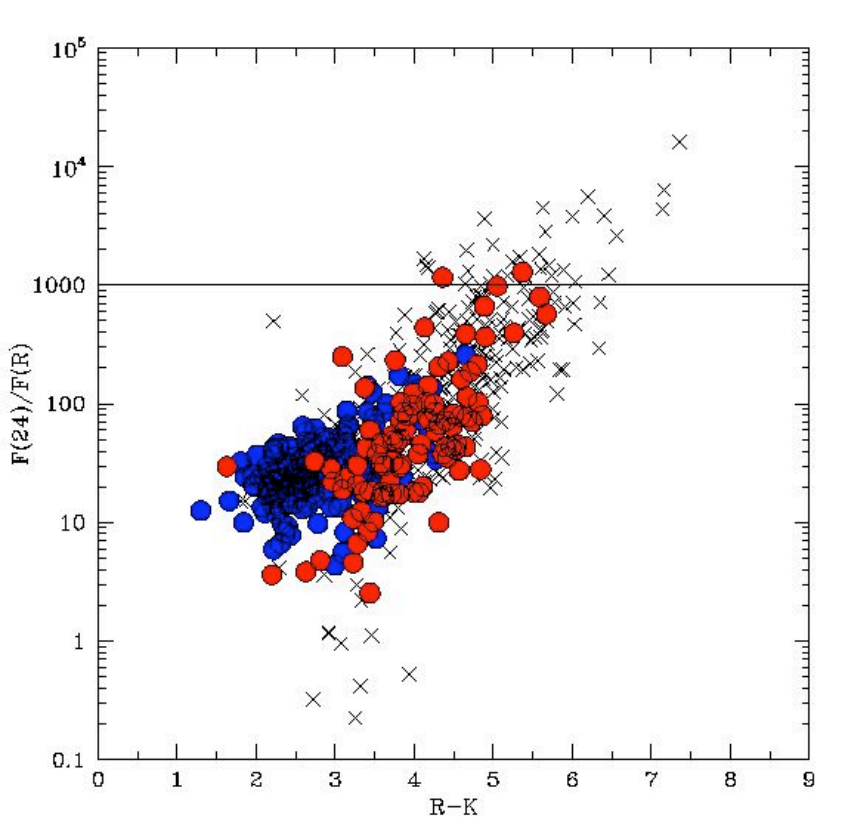


Luminosity effect also in IRAC: Luminous obscured AGN are redder



Going at longer wavelength..

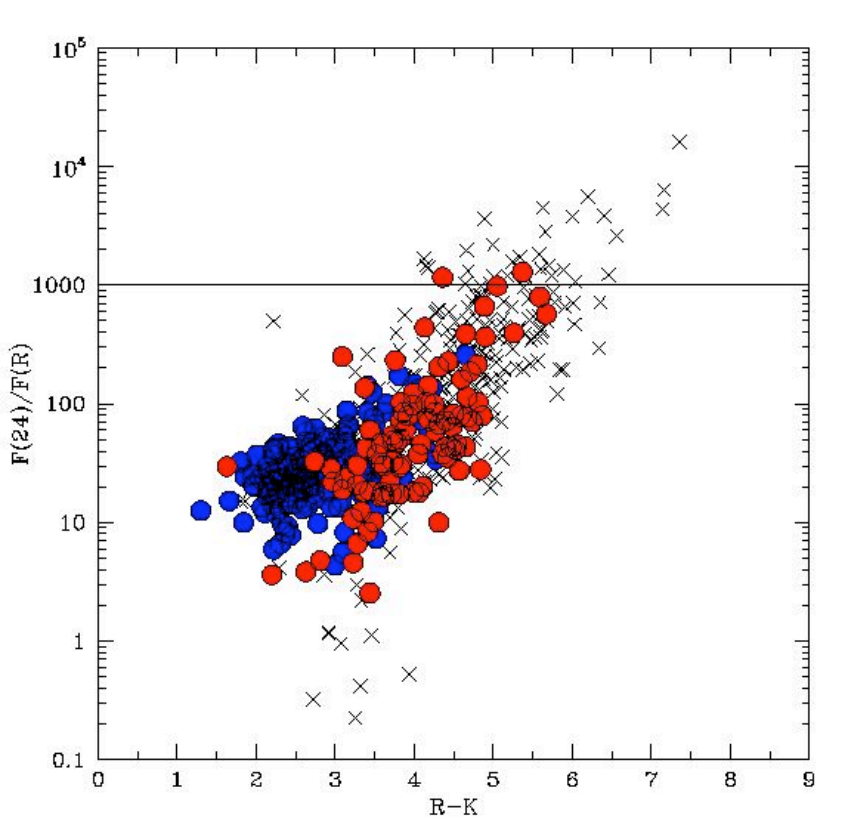
24micron/optical (MIR/O) flux ratio correlate with R-K

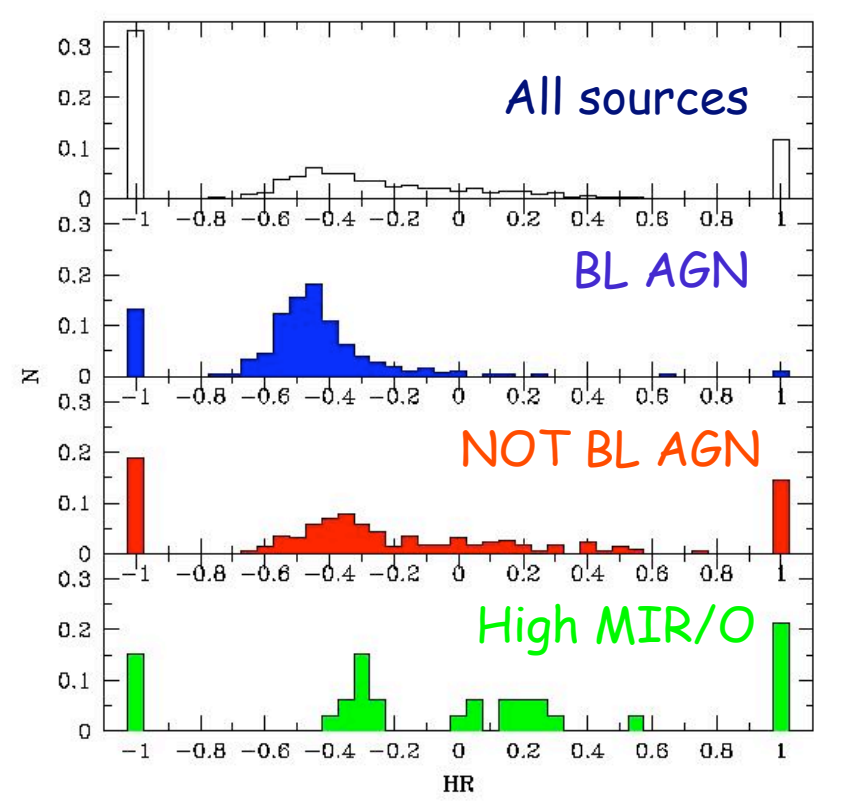


See also Martinez-Sansigre et al. 2005, Houck et al. 2005, Yan et al. 2005

Going at longer wavelength..

24micron/optical (MIR/O) flux ratio correlate with R-K



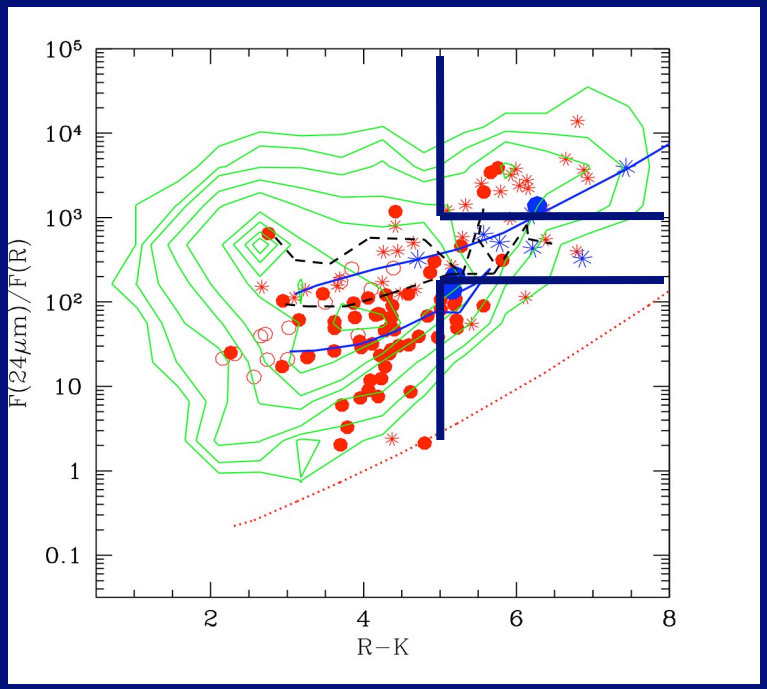


See also Martinez-Sansigre et al. 2005, Houck et al. 2005, Yan et al. 2005

Combining MIR/O and R-K criteria:

GOODS CDFS field

Stack of Chandra images excluding X-ray detections in two different MIR/O and R-K bins



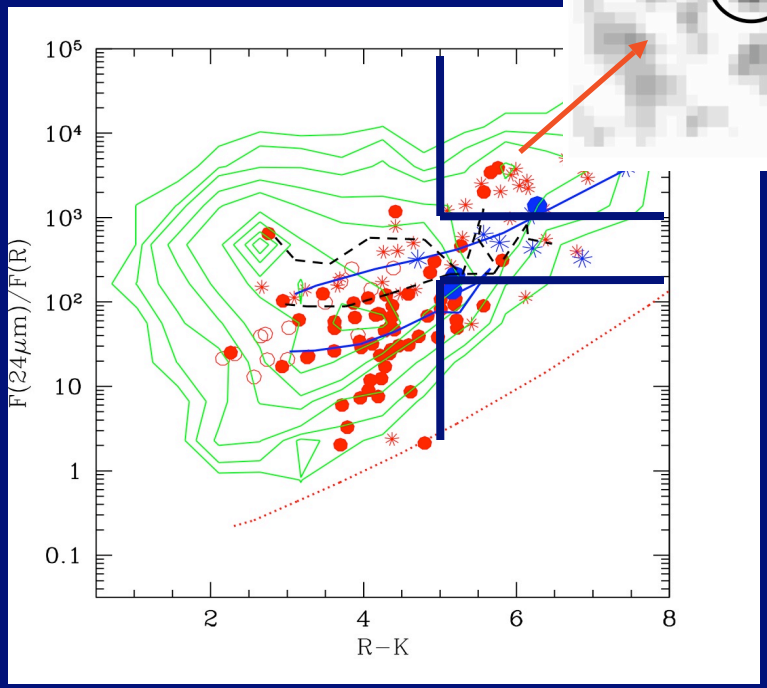
Fiore et al. 2007

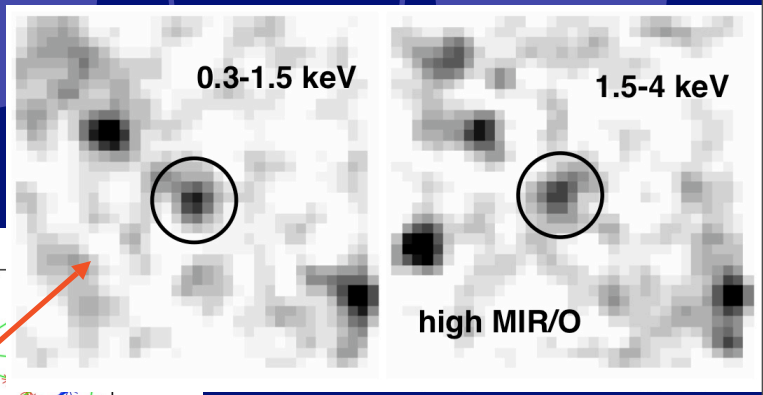
See also Daddi et al. 2007
(and Dave Alexander's talk yesterday)

Combining MIR/O and R-K criteria:

GOODS CDFS field

Stack of Chandra images excluding X-ray detections in two different MIR/O and R-K bins





Stacked signal implies (unobs) Lx>43, NH>24
→ Compton Thick

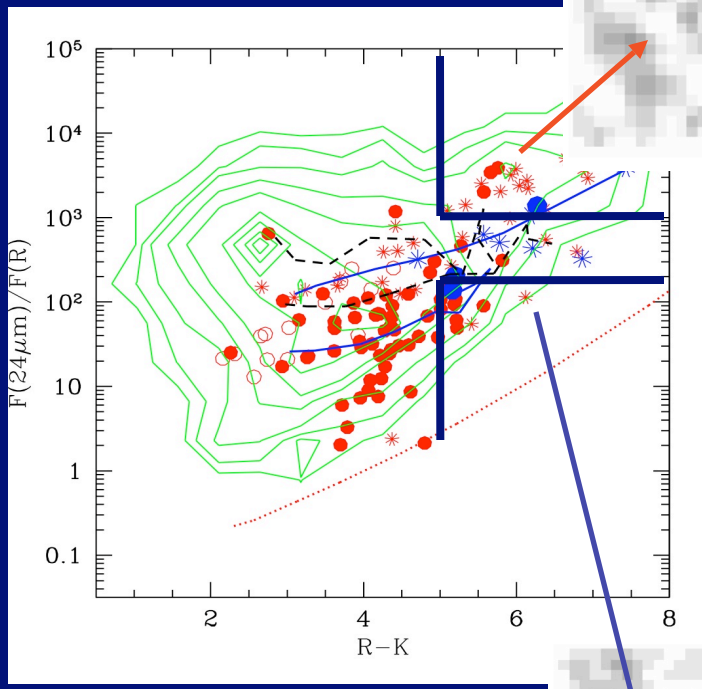
Fiore et al. 2007

See also Daddi et al. 2007
(and Dave Alexander's talk yesterday)

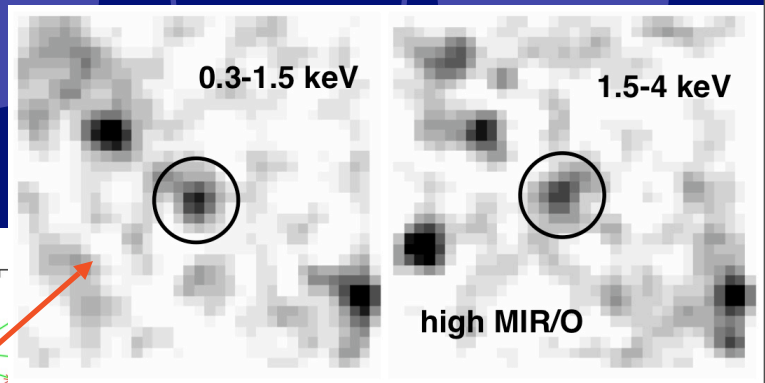
Combining MIR/O and R-K criteria:

GOODS CDFS field

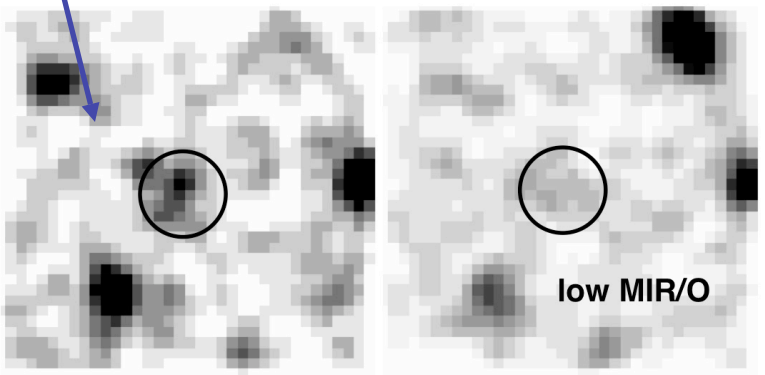
Stack of Chandra images excluding X-ray detections in two different MIR/O and R-K bins



Fiore et al. 2007



Stacked signal implies (unobs) Lx>43, NH>24
→ Compton Thick



See also Daddi et al. 2007
(and Dave Alexander's talk yesterday)

Summary of results

- XMM-COSMOS optimal dataset to study X-ray selected obscured AGN (large statistics, homogeneous coverage)
- The combination of X-ray and near-infrared/Spitzer observation is crucial to select and characterize obscured sources
- SED of obscured sources are not always PL in IRAC (galaxy dominates)
- MIR/O + R-K selection efficient to detect Compton thick AGN
- Most luminous sources are redder →
  effect of relative contribution of AGN and host or
  feedback more efficient to stop starformation?
  (probably a combination of both)

(Possible) Implications

Scenario: - galaxy mass assembly
- star formation and BH growth
- unobscured (highly accreting) QSO phase
- AGN quenches star formation

passive evolution and rapid reddening of colors (EROs)

Timescales of various phases depend on BH mass + cold gas available

Luminosity effects observed fit in "downsizing" scenario

Granato et al. 2004; Marconi et al. 2004 2007 Merloni 2004
Di Matteo et al. 2005, Hopkins et al. 2006, Menci et al. 2006