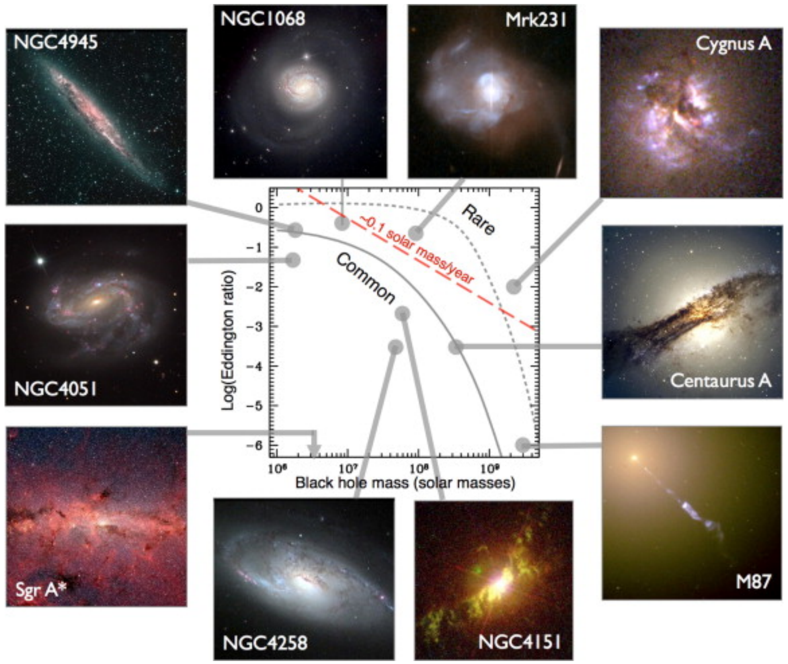
AGN demography and SED: from the X-ray to the optical

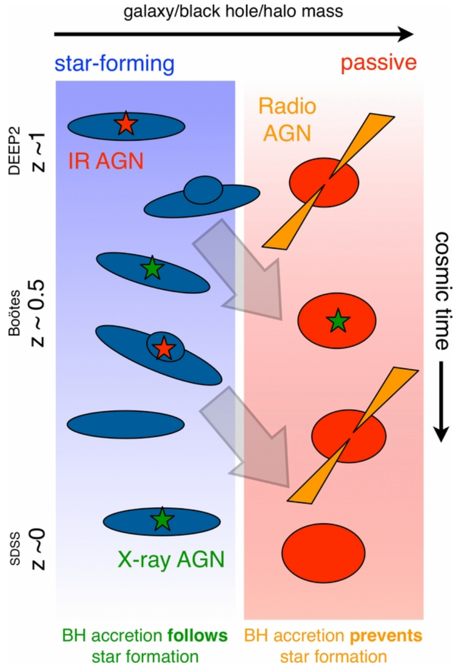
Vincenzo Mainieri

AGN11: Where Black Holes and Galaxies meet, Trieste 2014

Context

Alexander & Hickox+12





Goulding+14

- What are the links between black-hole growth and their host galaxies and large-scale environments?
- What is the detailed nature of AGN feedback and its effects on black-hole fuelling and star formation?

Context

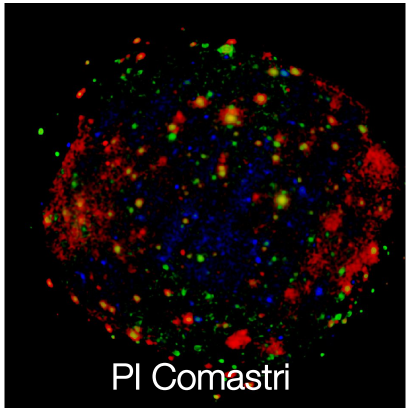
GOAL : Link the physical properties of the central SMBH with those of its host galaxy

In order to achieve this goal there are some "preliminary" steps that we have to do:

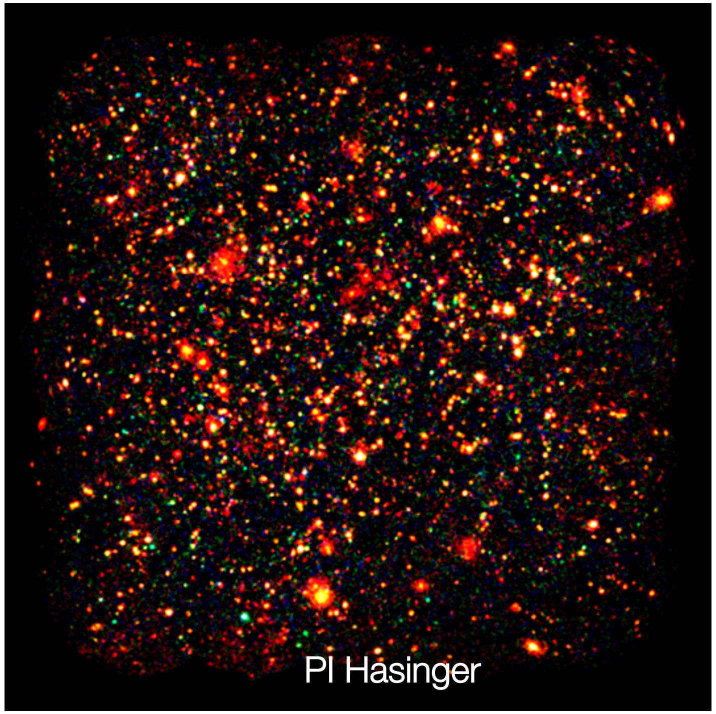
- Detect "all" AGNs: the AGN population traces the cosmic SMBH growth history
- Disentangle AGN and galaxy emission … characterize the properties of their host galaxies (e.g. SFR, M_{star})
- Characterize their evolution … and compare it to that of their host galaxies

Tool: X-ray surveys

CDF-S



COSMOS



- X-ray is the cleanest way to select AGNs
- [0.5-10 keV] biased against C-thick sources

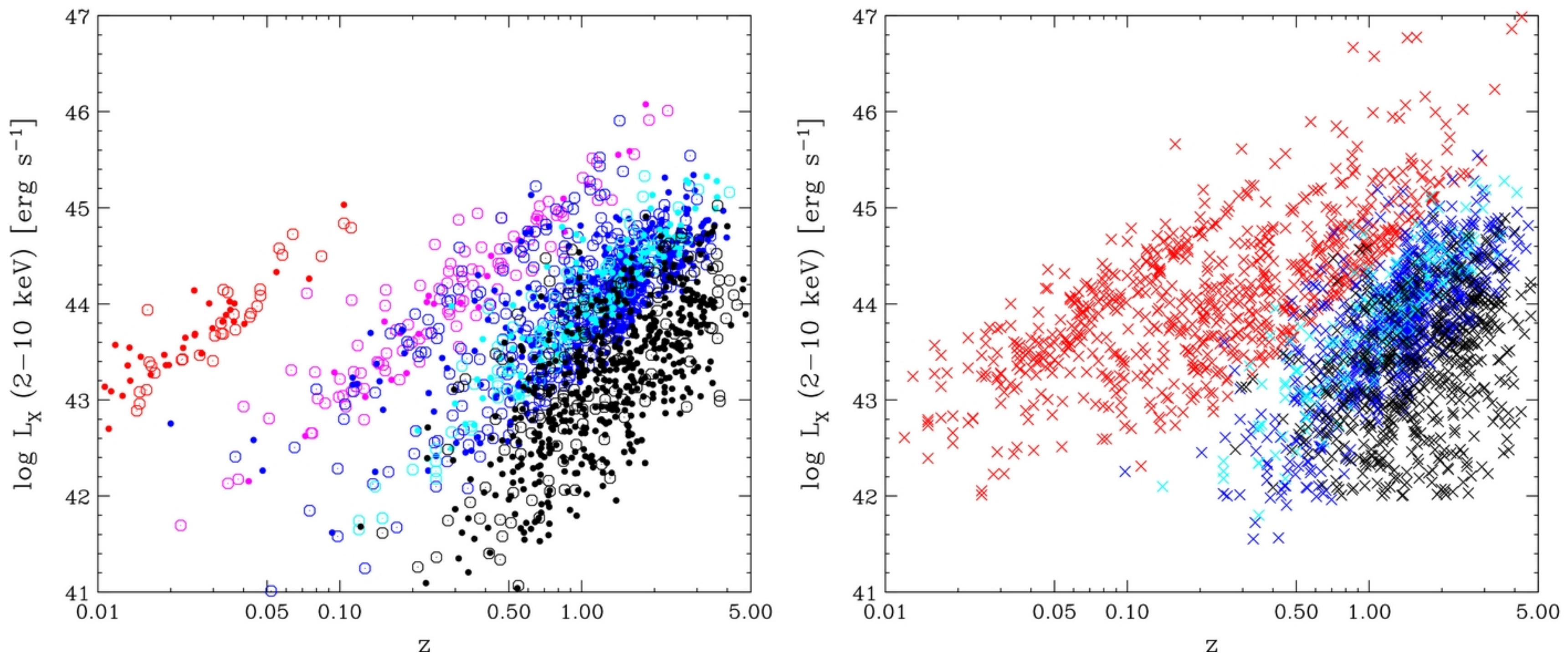
AREA →

← Sensitivity

AGN demography

The AGN Luminosity Function as the main demographic quantity

(e.g. Maccacaro+91; Boyle+93; Miyaji+00; Wolf+03; Ueda+03; Hasinger+05; La Franca+05; Richards+06; Bongiorno+07; Della Ceca+08; Silverman+08; Aird+10; Assef+11; Fiore+12; Ueda+14)

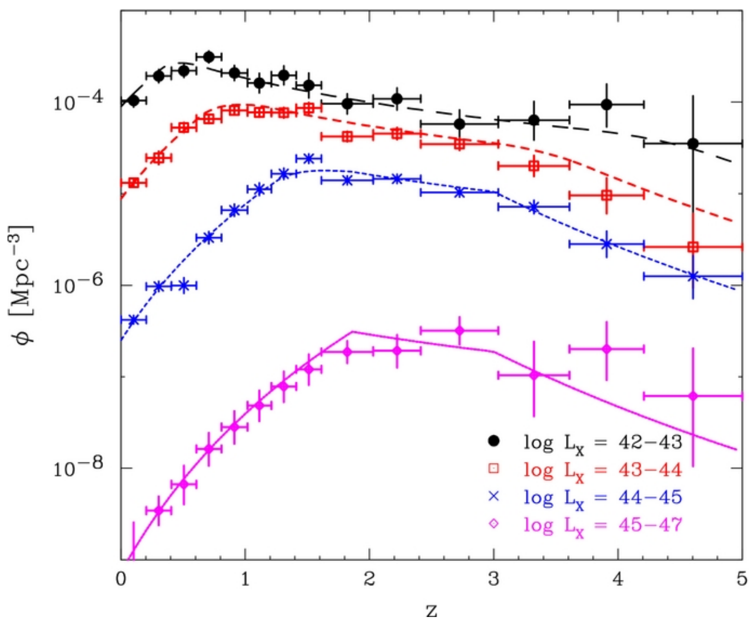


Ueda+14

Co-moving space number density of C-thin AGN

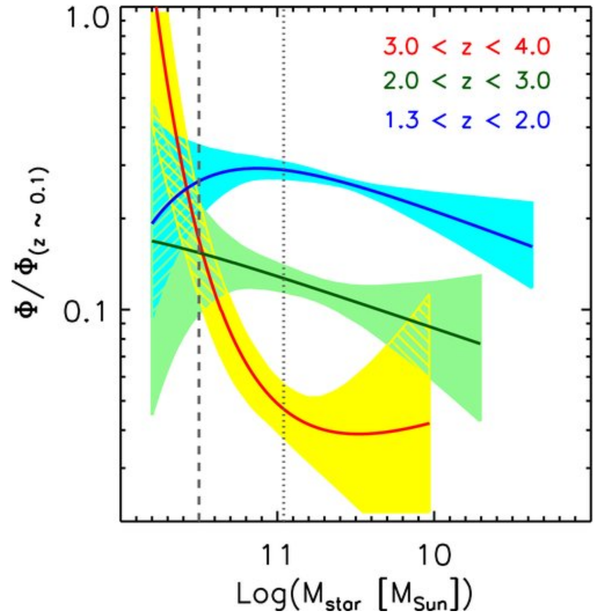
AGN “downsizing”

Ueda+14



The most luminous AGNs at the peak of their activity at higher redshift

M_{star} “downsizing”



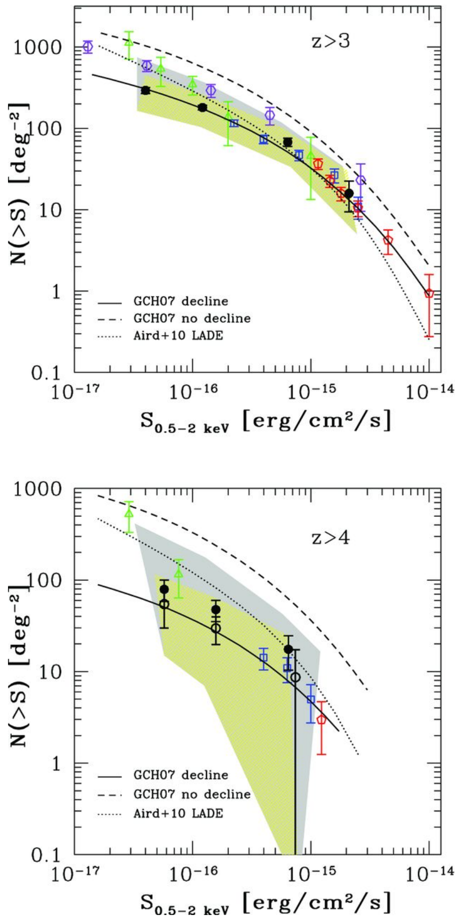
Marchesini+09

The most massive galaxies assemble their mass at higher redshift.

F. Shankar & M. Hirschmann talks

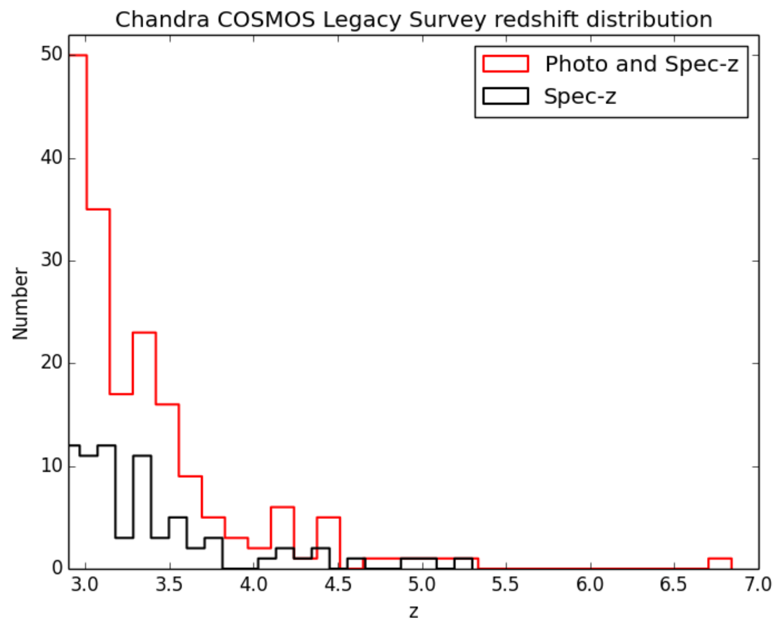
Space density of high-z AGNs

Vito+13



Fabio Vito's talk

Chandra Cosmos Legacy Survey
4031 sources
z>3 : 55 z-spec, 129 z-phot+z-spec

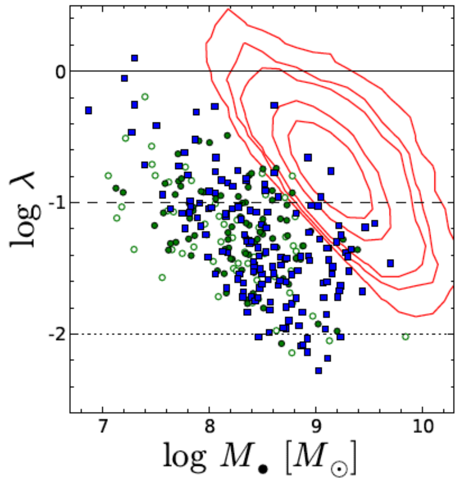


Civano et al.; Marchesi et al. in prep

XVP (2.8 Ms in COSMOS)
PI Civano

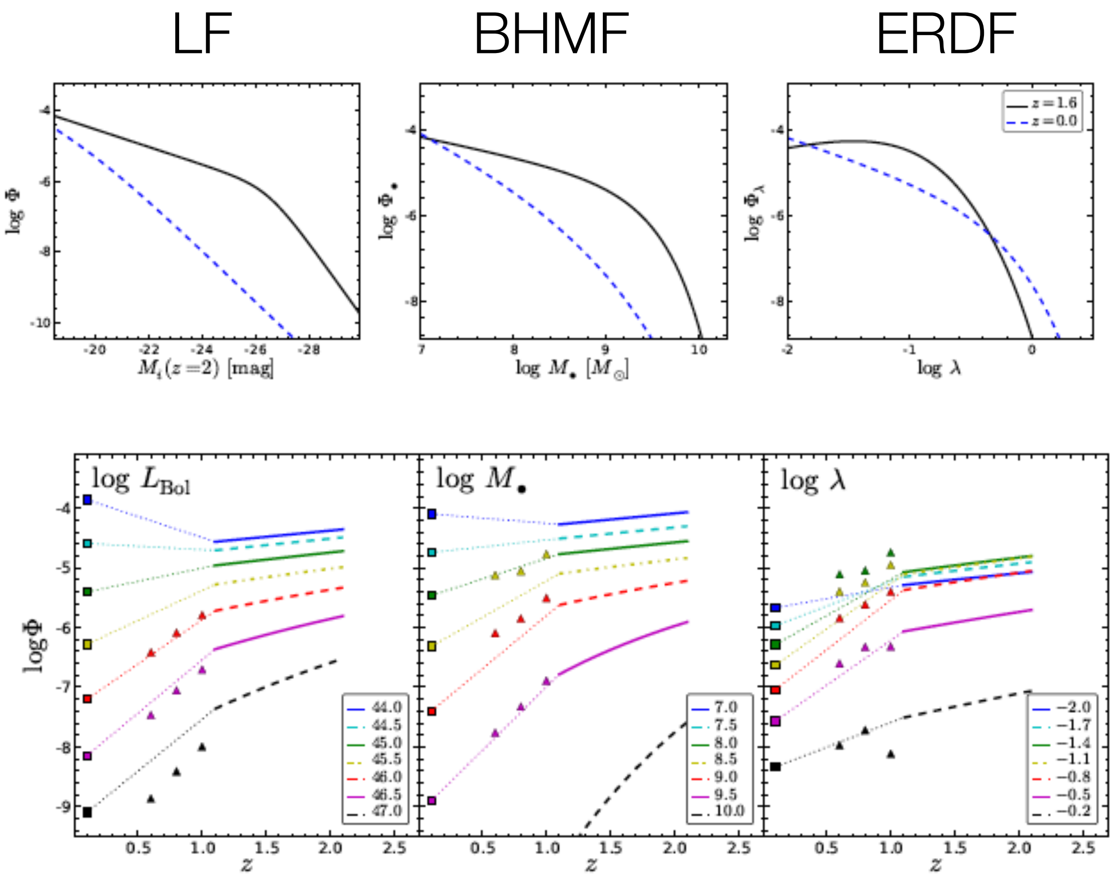
Cosmic evolution in BHM and λ

SDSS +VVDS+zCOSMOS



BHM “downsizing”:
Stronger decrease of the space density at the high MBH mass end compared to lower BH masses

ERDF: at z~2 flattening for λ<0.1 compared
to z=0 → higher average λ



Schulze+14

The obscured fraction of AGN

- Demographic studies: $N_{type2}/(N_{type1}+N_{type2})$

e.g. Lawrence & Elvis 1982; Ueda+03; Steffen+03; Simpson 2005; Hasinger 2008; Bongiorno+10; Brusa+10; Burlon+11; Assef+13; Merloni+13

- SED-based studies:

$$f_{\rm obsc} \simeq \frac{R}{1 + R(1-p)}$$

$R=L_{IR}/L_{bol}$

L_{IR} = re-processed AGN emission
L_{bol} = AGN emission (opt-UV+X-ray)
p= 1 (optically thin) ; p<<1 (optically thick)

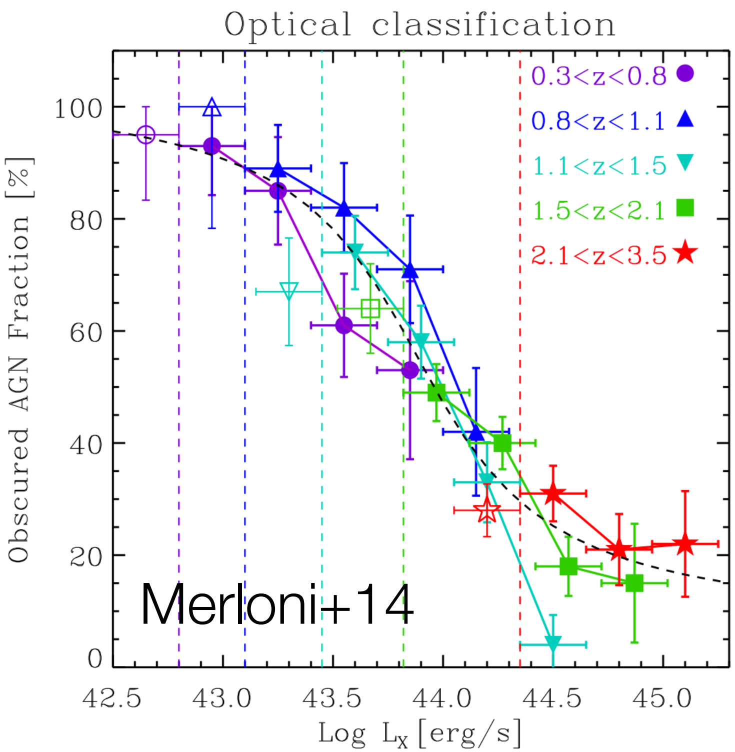
e.g. Maiolino+07; Treister, Krolik & Dullemond 2008; Sazonov+12; Lusso+13; Roseboom+13

- EW Fekα ("Iwasawa-Taniguchi effect")

e.g. Iwasawa & Taniguchi 1993; Bianchi+07

See Bianchi+12 for a review

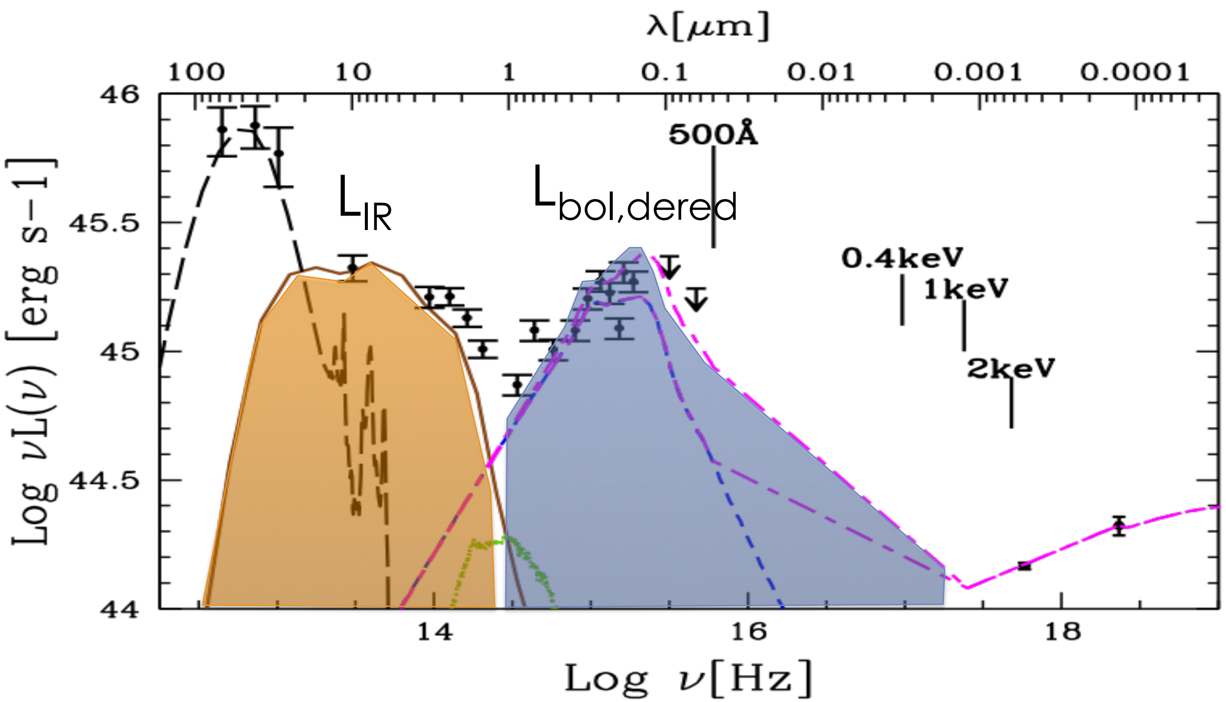
f_{obsc} vs Lx : demography



- 1300 AGNs in XMM-COSMOS
- Type-1 / Type-2 classification based on : optical spectra + SED or X-ray spectra
- Rest-frame absorption corrected L[2-10 keV], trying to limit the bias of flux limited X-ray samples.

The fraction of optically obscured AGN decreases with luminosity

Obscured fraction vs L_{bol}: SED studies



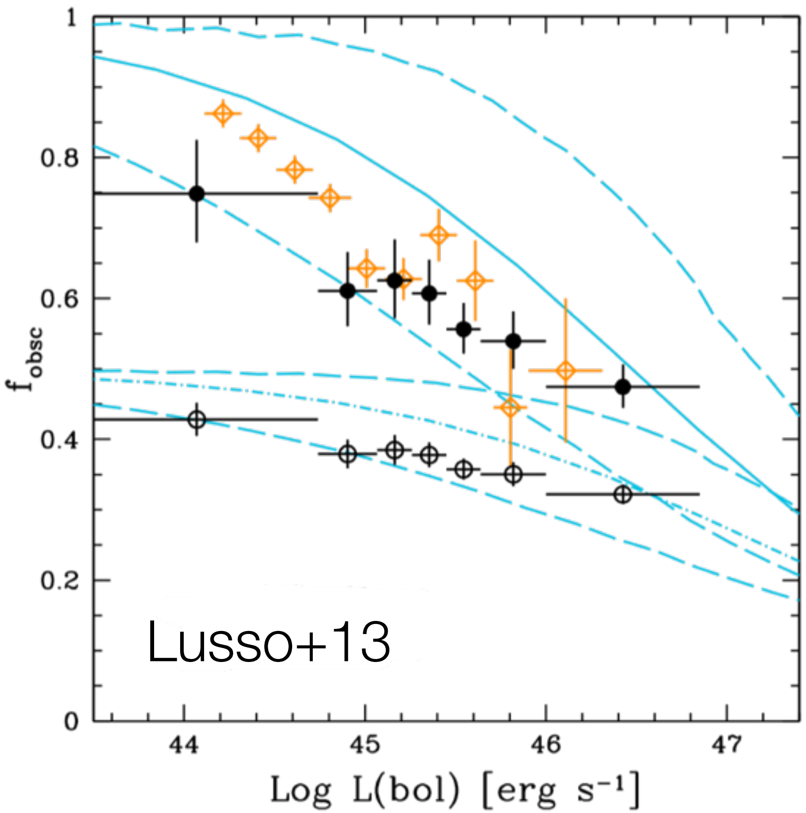
Lusso+13

- Correct L_{bol} for host galaxy/ reddening contamination
- Estimate f_{obsc} without assuming any bolometric correction

$$f_{obsc} \simeq \frac{R}{1 + R(1-p)}$$

p= 1 (optically thin)
p<<1 (optically thick)

Obscured fraction vs Lbol



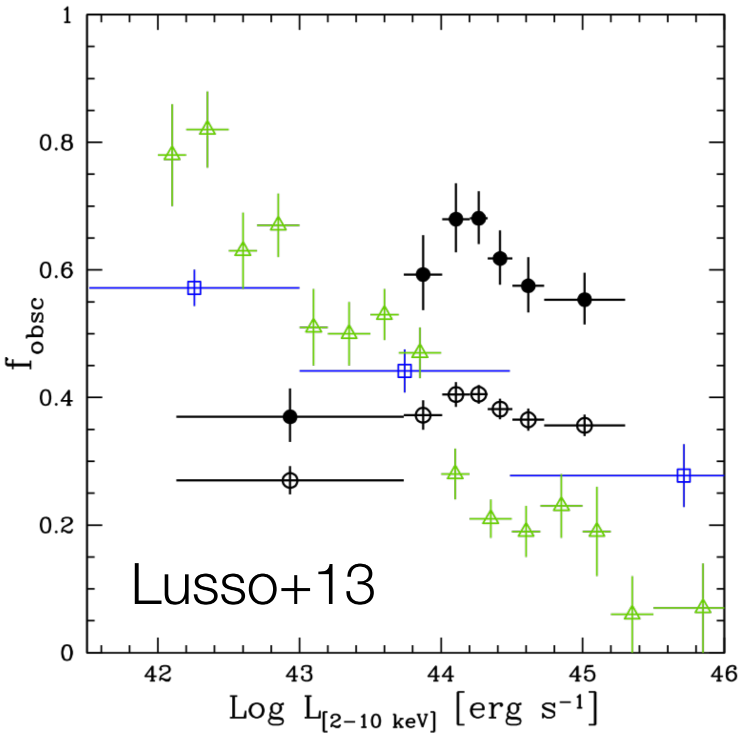
Maiolino(2007)
SED-based vs L5100Å
f_{obsc}~L6.7μm/L5100Å

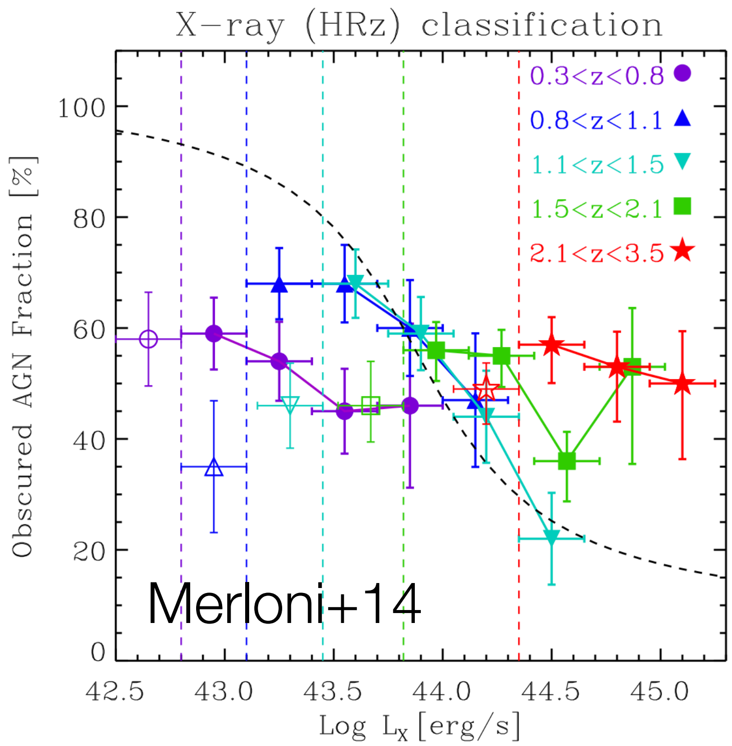
Simpson (2005)
Demographics vs L[OIII]

Lusso (2013)
Filled circles: thin regime
Empty circle: thick regime

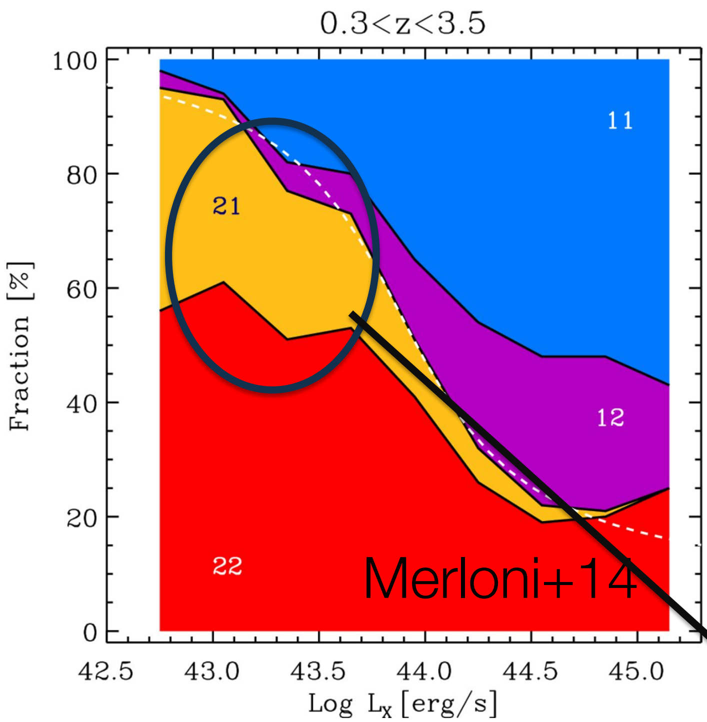
SED-based studies also confirm a decrease of f_{obsc} with luminosity

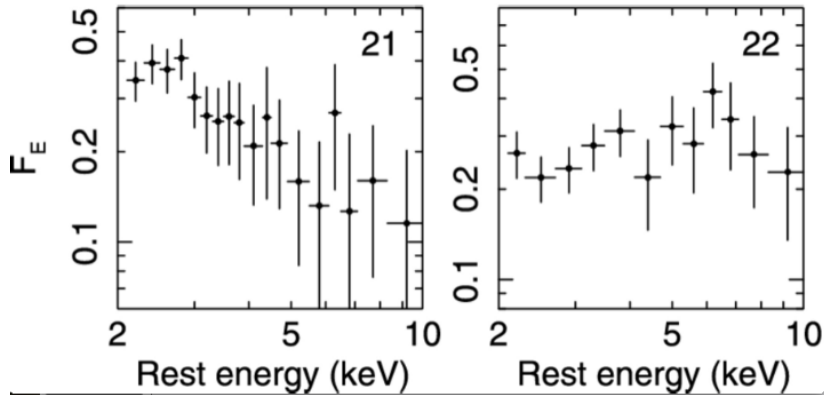
Obscured fraction vs L[2-10 keV]





AGN classification

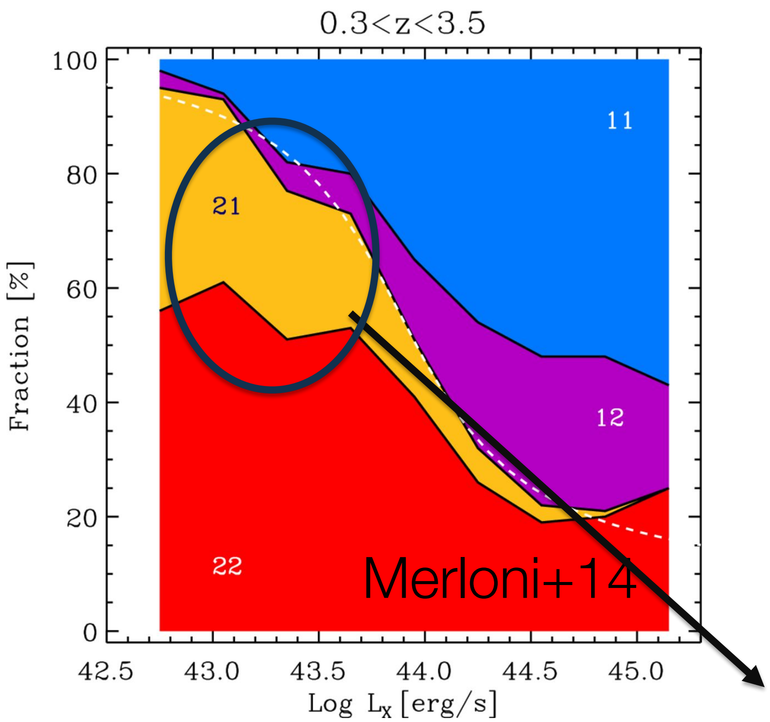


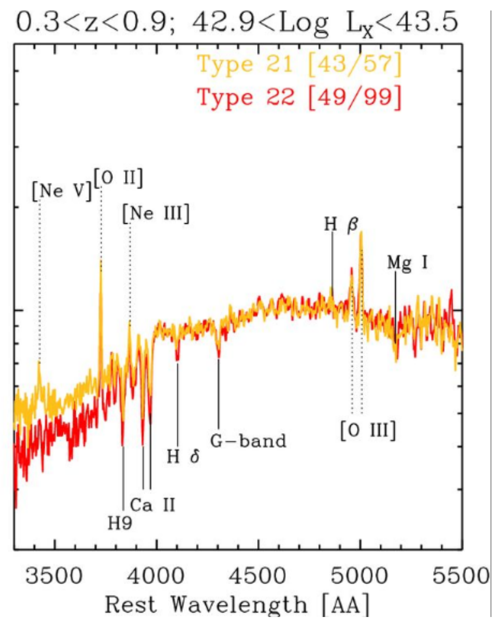


"True" Type-2 (e.g. Panessa & Bassani 2002, Nicastro+00, Nenkova+08, Elitzur & Ho +09), C-thick, BL diluted by galaxy light

X-ray & optical type 1
X-ray & optical type 2
X-ray type-1 , no BL
X-ray obscured, BLAGN

AGN classification





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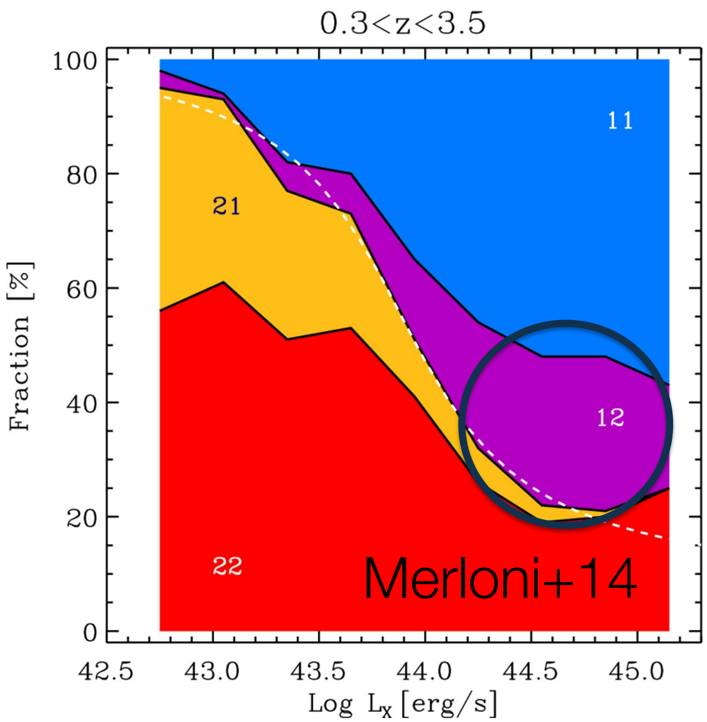

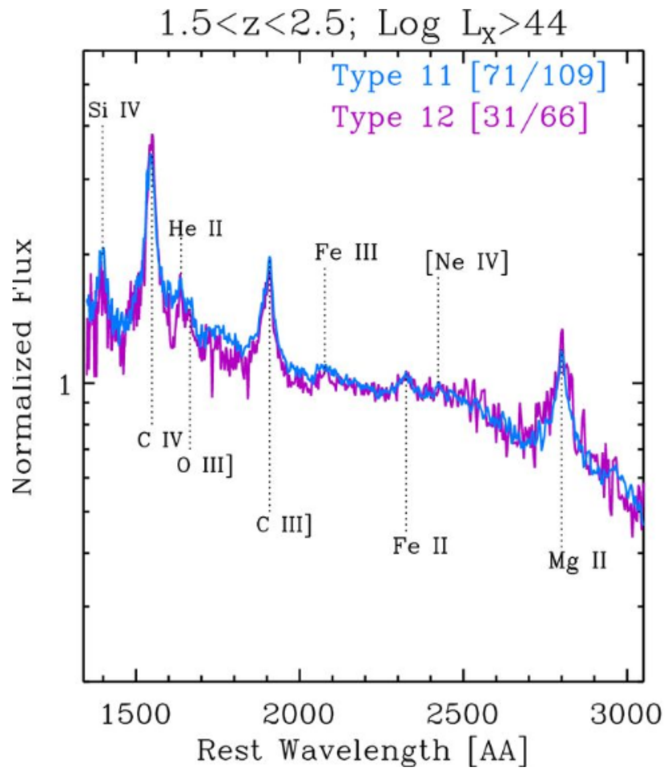

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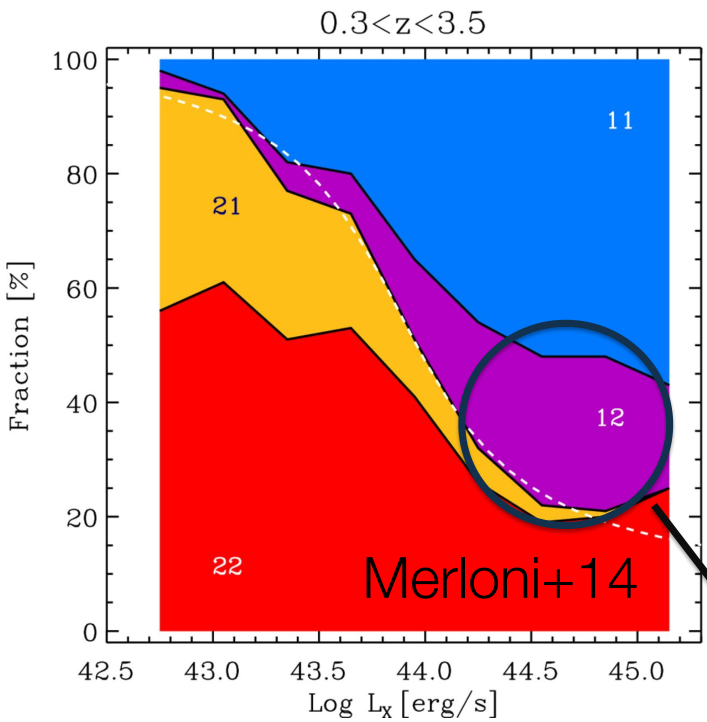

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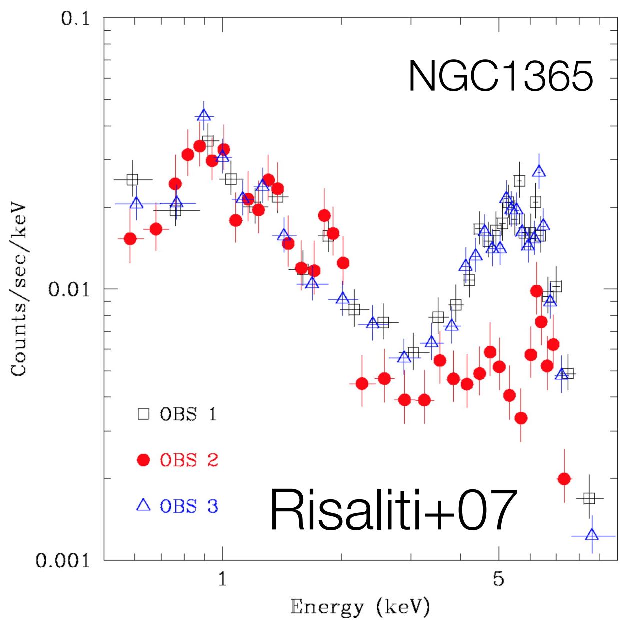
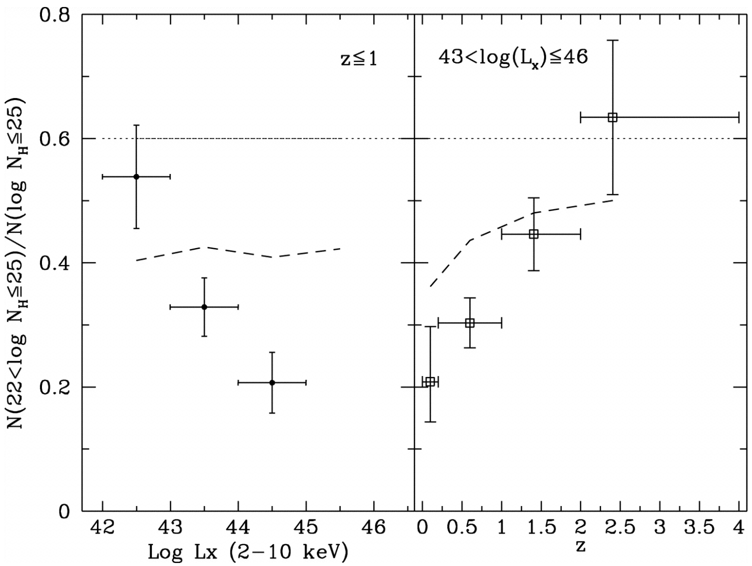


e.g. Puccetti+07, Bianchi+09, Maiolino+10

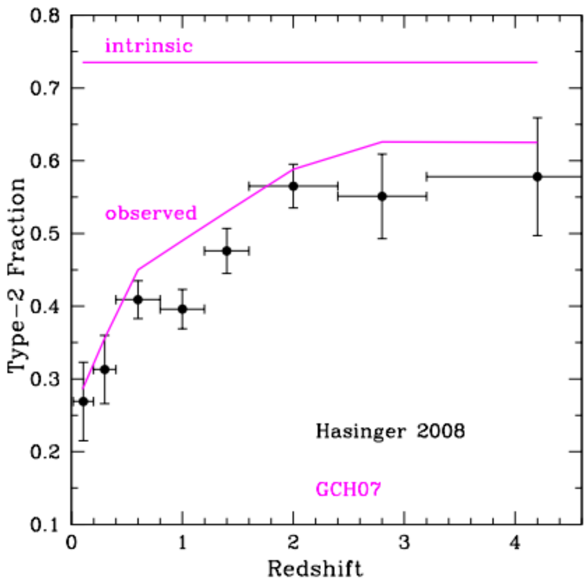
X-ray absorber within or inside the BLR

Perola+04, Fiore+12, Lanzuisi+13

Obscured fraction vs z



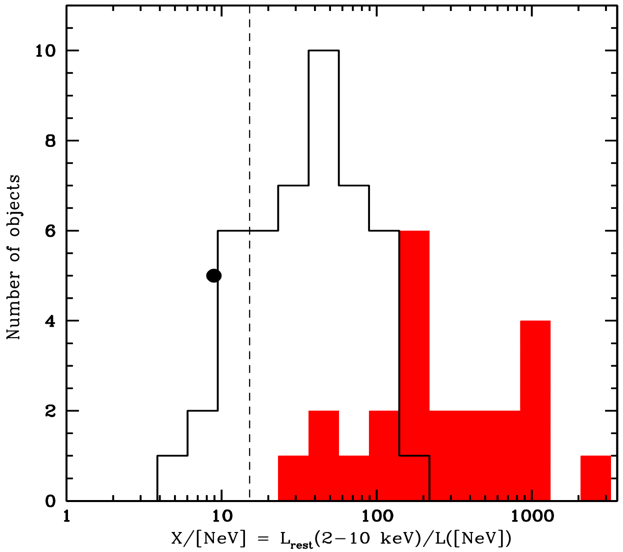
La Franca+05



Gilli+10

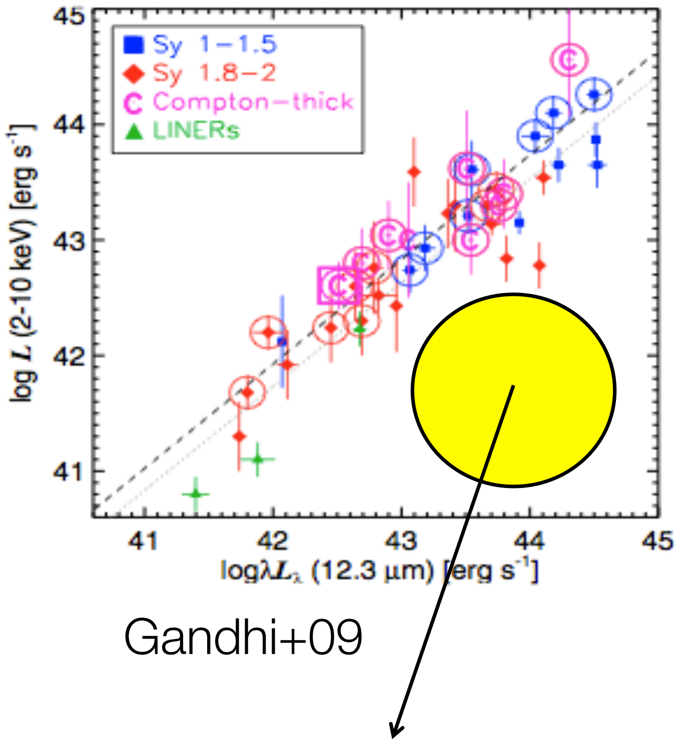
Yes: La Franca+05; Treister & Urry+06; Hasinger+08; Trump+09; Iwasawa+12; Ueda+14
No: Ueda03; Dwelly & Page+06; Gilli+07
Maybe: e.g. Merloni+14 (at high Lx)

C-thick AGNs : X/[NeV]



Gilli+10, Mignoli+13

- X/[NeV] as a tool to select C-thick objects: [NeV] as a procy of the intrinsic emission
- 9/72 (13%) are good C-thick candidates (X/[NeV]<15)
- X-ray stacking + Monte-Carlo simulations indicate that the overall fraction of Compton-thick AGN is ≈43%

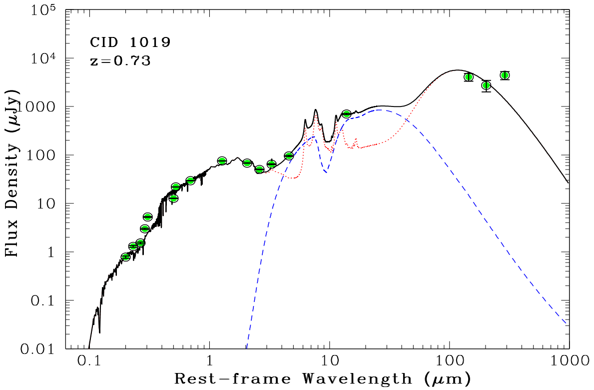


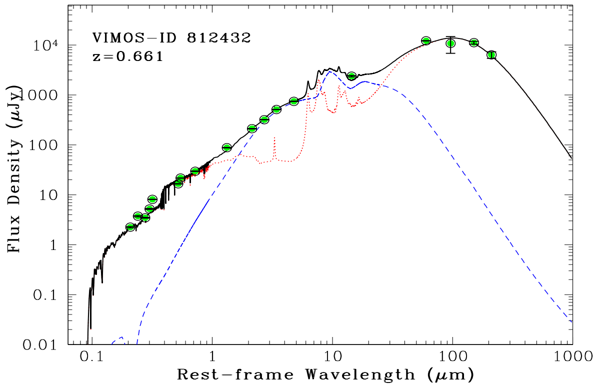
Gandhi+09

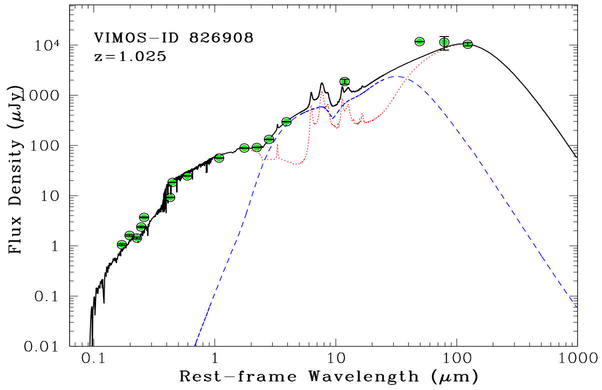
MIR >> expected Lx

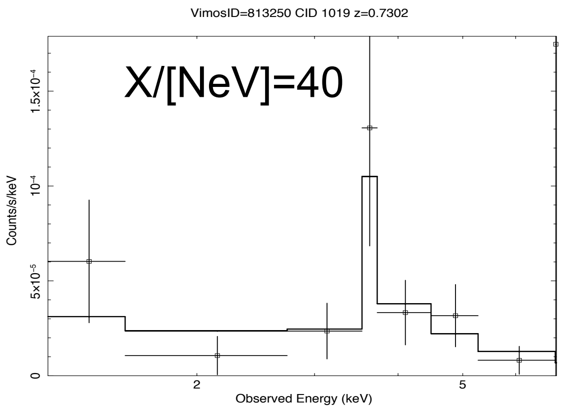
SED decomposition

C-thick AGNs : X/[NeV] and MIR excess









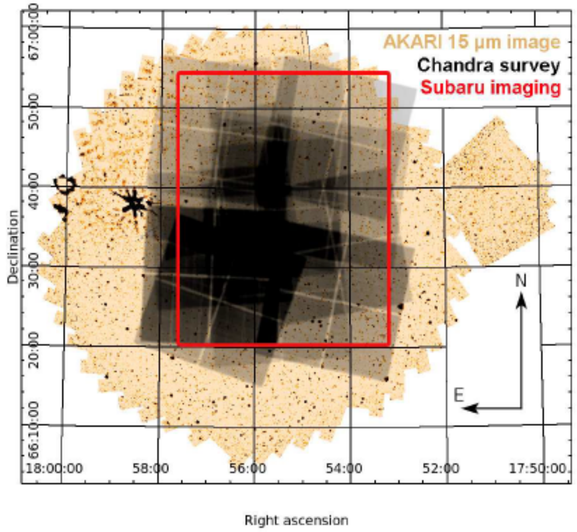
X/[NeV]<10

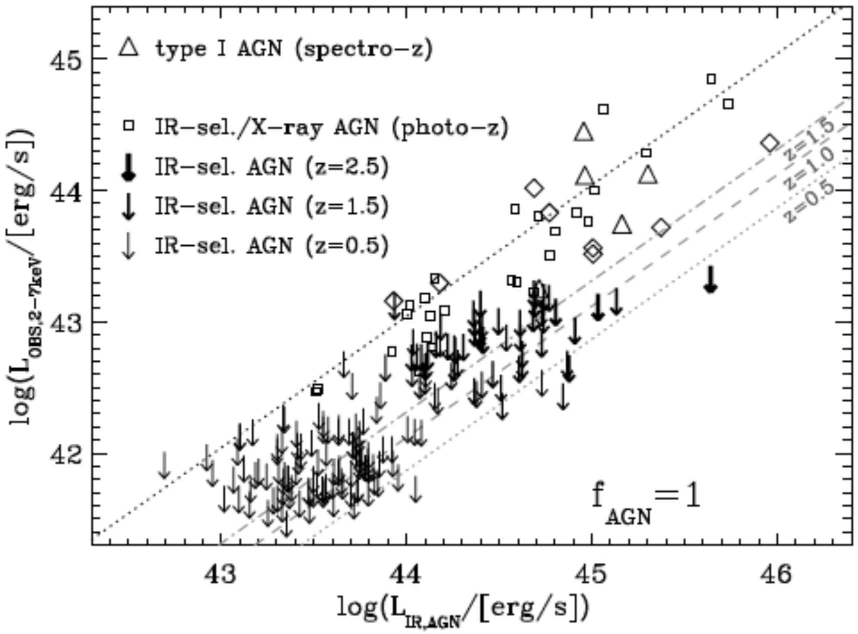
X/[NeV]<90

Vignali et al. in prep

C-thick AGNs : Chandra+AKARI

AKARI: 2-25 μm

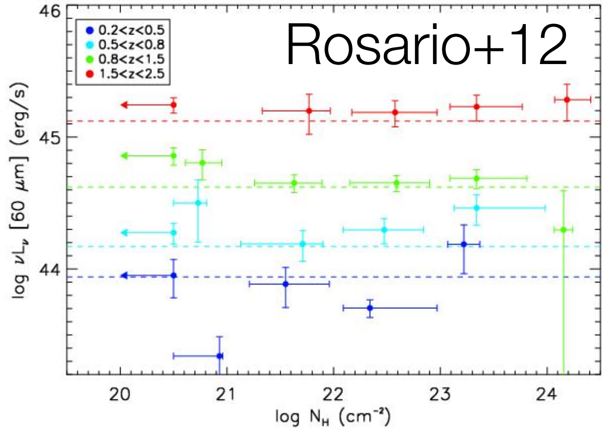


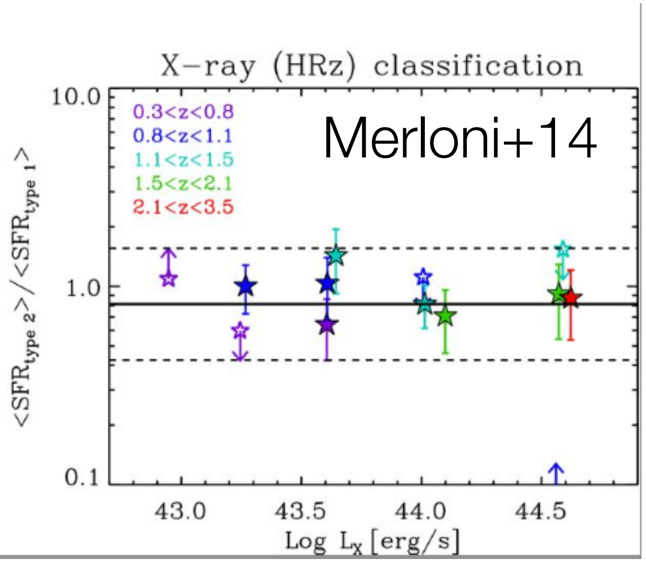


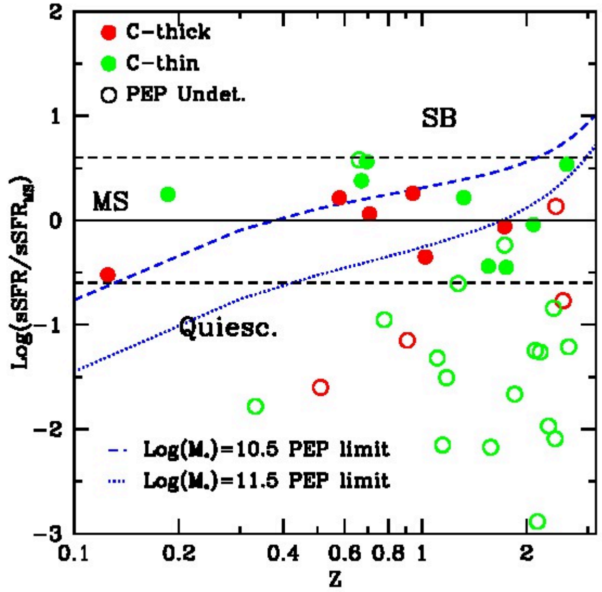
Krumpe+14

30% of all AGN that have MID-IR SEDs purely explainable by AGN activity are Compton-thick AGN candidates.

C-thick AGNs : host galaxies properties.





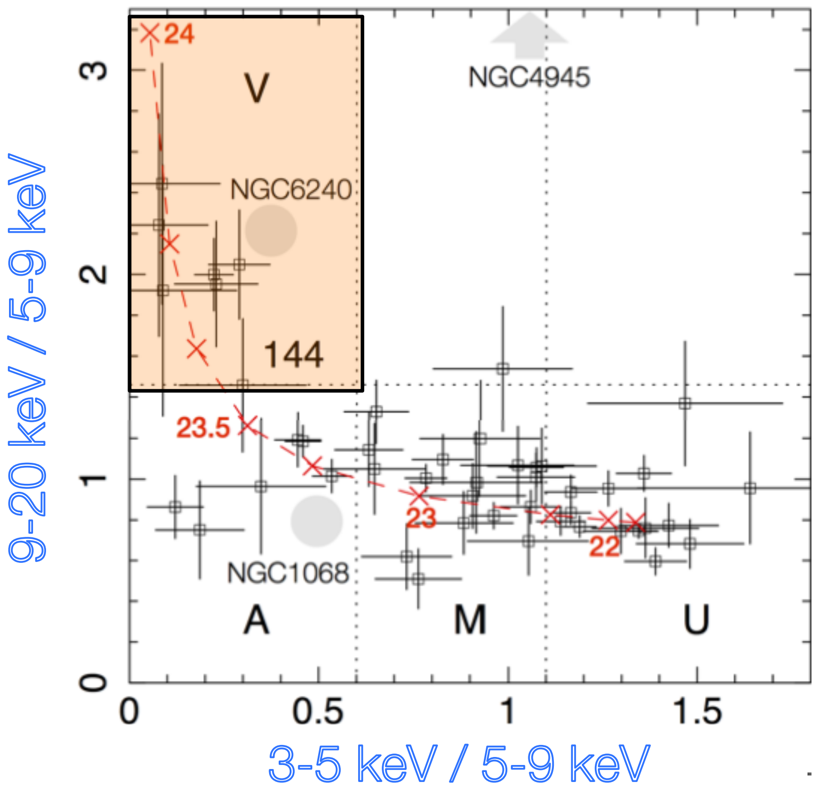


Lanzuisi+14

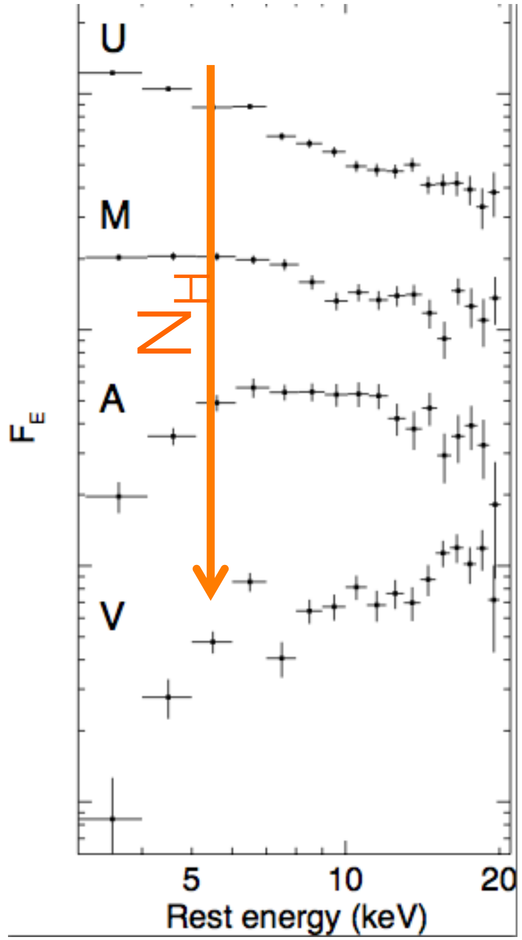
The properties of the obscuring medium does not correlate with the host galaxy total SFR

Manuela Magliocchetti's talk

X-ray stacking

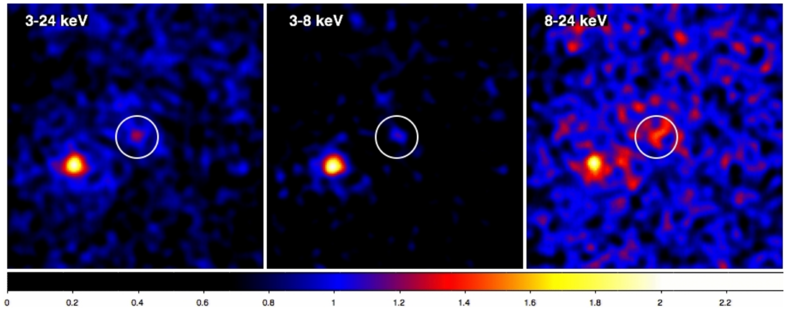


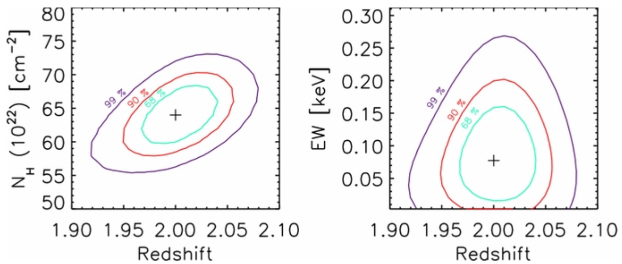
Obscured AGN at z>1.7 : rest-frame 9-20 keV excess sources



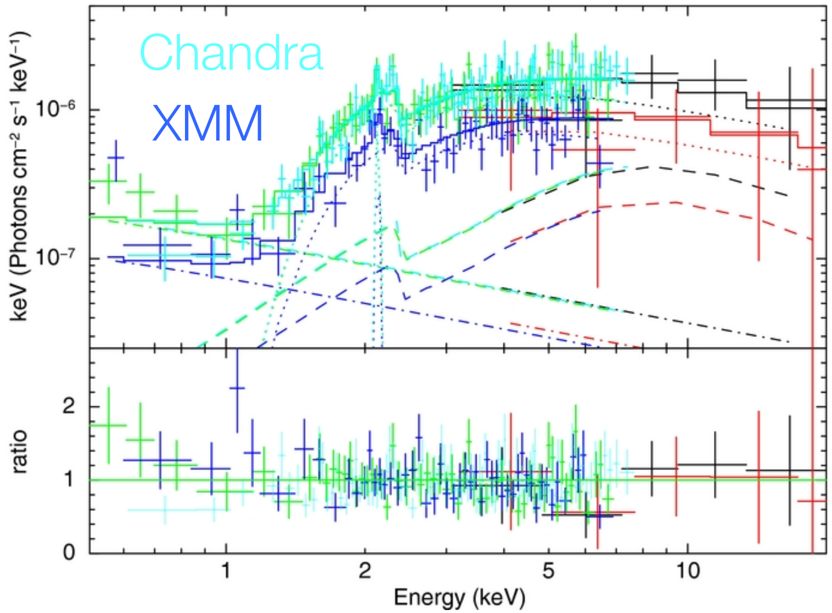
Iwasawa+12

Going above 10 keV: NuSTAR





NuSTAR+Chandra/XMM:
$N_H \approx 6 \times 10^{23}$ cm^{-2}
~2–3 times higher than that previously found using Chandra or XMM data alone

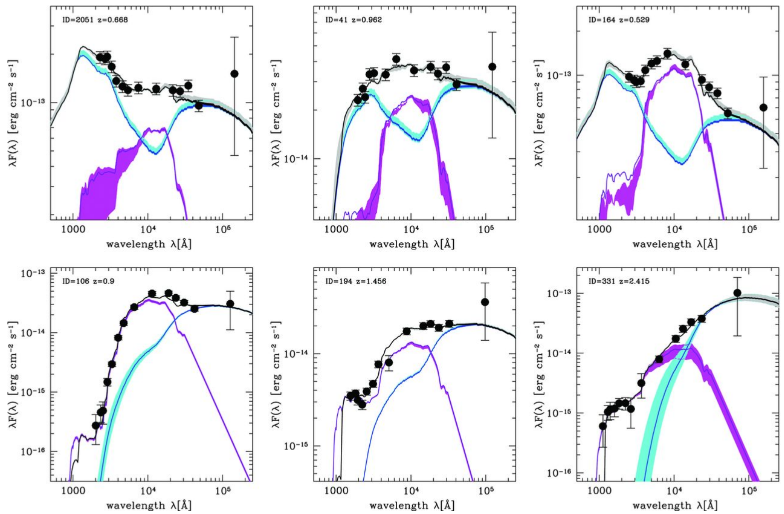


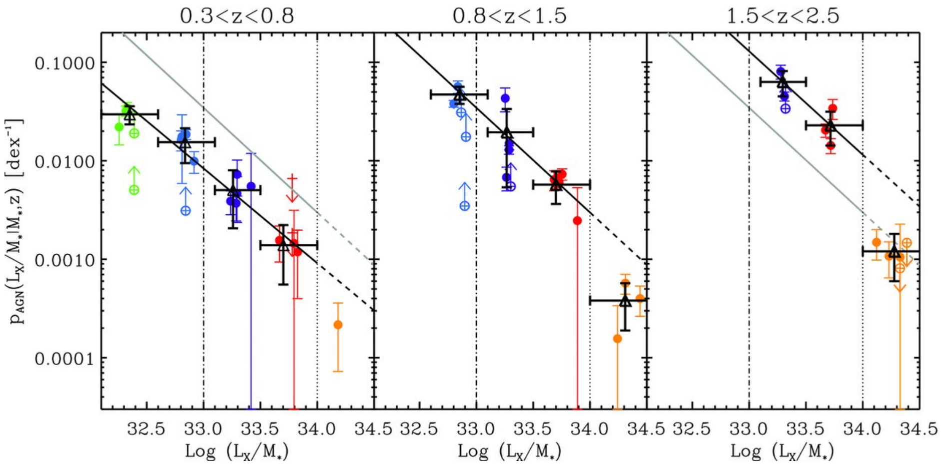
Del Moro+14

Luca Zappacosta's talk

SED decomposition: AGN fraction

- ~1500 X-ray selected AGNs
- 54% spec-z, 46% photo-z
- ~600 unobscured, 900 obscured
- Wide and deep multi-wl coverage





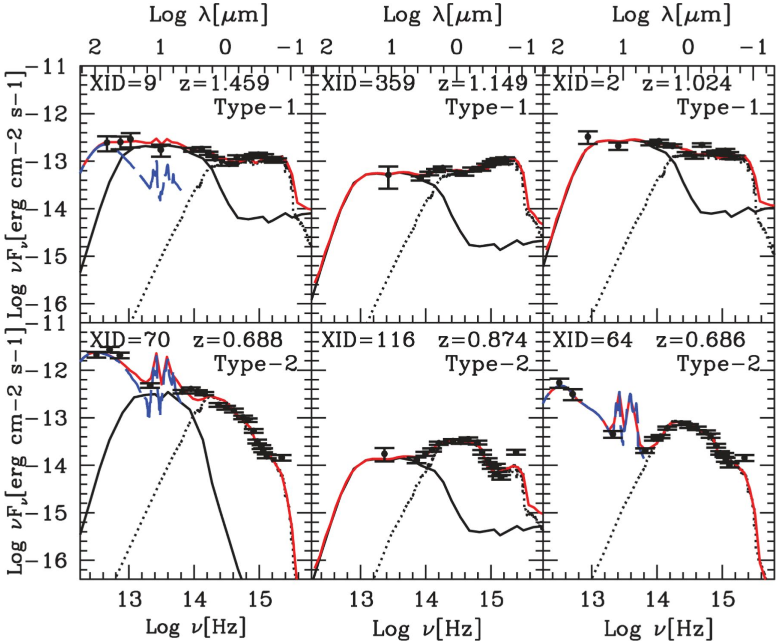
Bongiorno+12

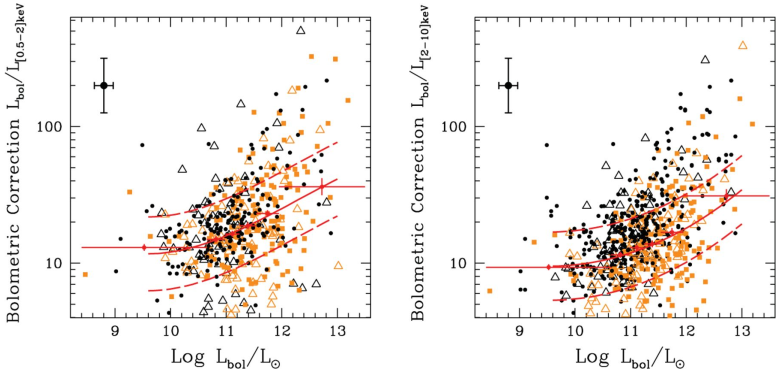
"Specific accretion rate" (Aird+12)

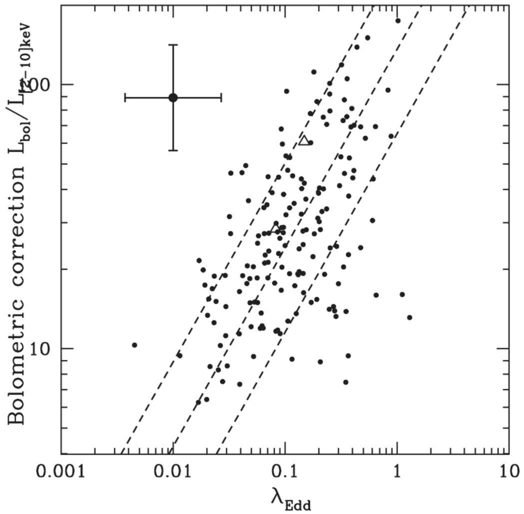
- AGN fraction is independent of M_{star}
- Its normalization evolve as $(1+z)^4$ (~ sSFR)

SED decomposition: k_{bol}

380 Type-1+ 550 Type-2 from XMM-COSMOS







Lusso+12

Higher k_{bol} at higher λ_{Edd}: the emission from the X-ray corona becomes weaker relative to the disc as the accretion rate increases

Summary

- Demographyc tools (LF, BHMF, ERDF) support the downsizing evolution of SMBHs
- AGN obscuring medium (pc and sub-pc) does not correlate with the host galaxy total SFR
- SED decomposition studies are fundamental to characterize the properties of the host galaxies (M_{star}, SFR) and those of the central SMBH (e.g. L_{bol})
- The obscured AGN fraction decreases as a function of luminosity → receding torus model?
- The obscured AGN fraction vs z: increasing at high-Lx (merger driven) but not at low-Lx (secular processes) ?
- C-thick: combine deep X-ray observations with indirect evidence (e.g. IR, [OIII], [NeV])
- Z>3 space density : improvement from new medium square degree surveys (e.g. COSMOS Legacy Survey)
- Future X-ray surveys: NuSTAR (present), eROSITA, ATHENA → M. Brusa and M. Cappi talks


Active Galactic Nuclei 11
23-26 September 2014, Trieste
Where Black Holes and Galaxies Meet

Thanks!