Compton thick AGN and the role of SPICA

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Overview

* Heavy, Compton thick (tau > 1, $N_H > 1.5 \times 10^{24}$ cm^{-2}), obscuration appears to be quite common in the local Universe

* A sizable population of CT AGN is required to fit the XRB

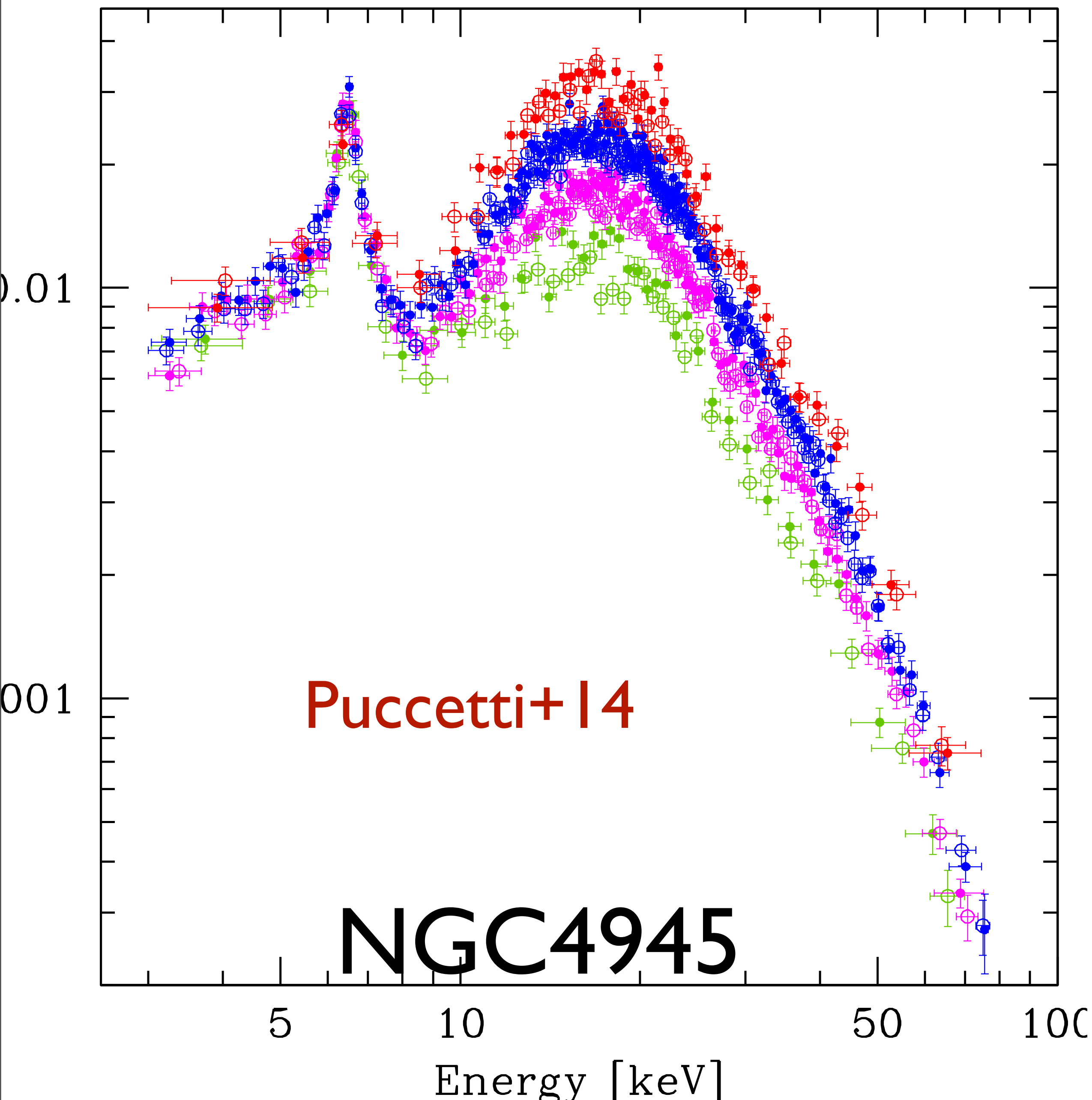
* CT obscuration may represent a key phase in the SMBH/host co-evolution

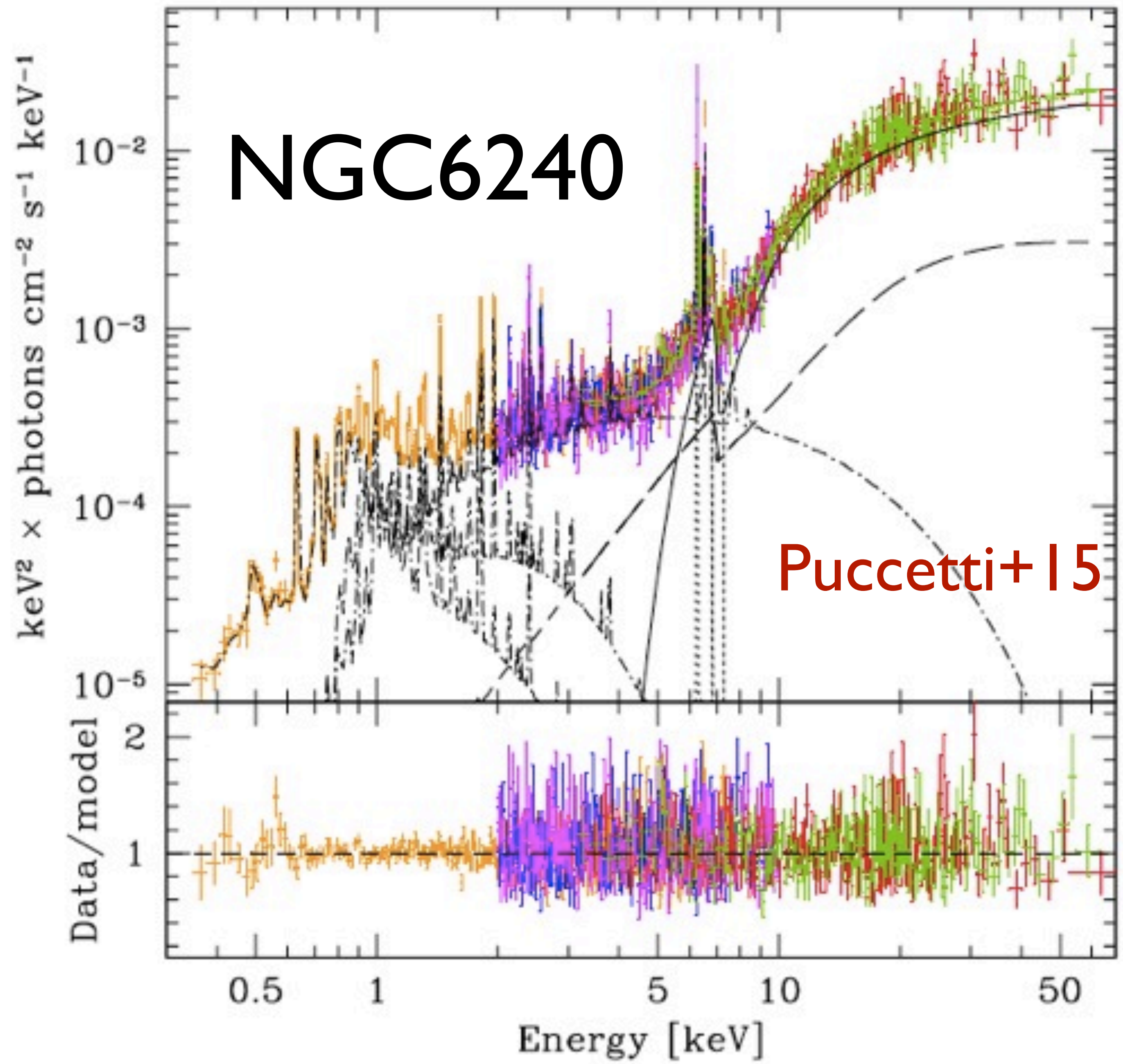
** Hard X-ray vs Optical/MIR selection

** Census in terms of accreted mass (Soltan argument)

*** SPICA and Athena Perspectives

Compton thick in the Backyard: NuSTAR





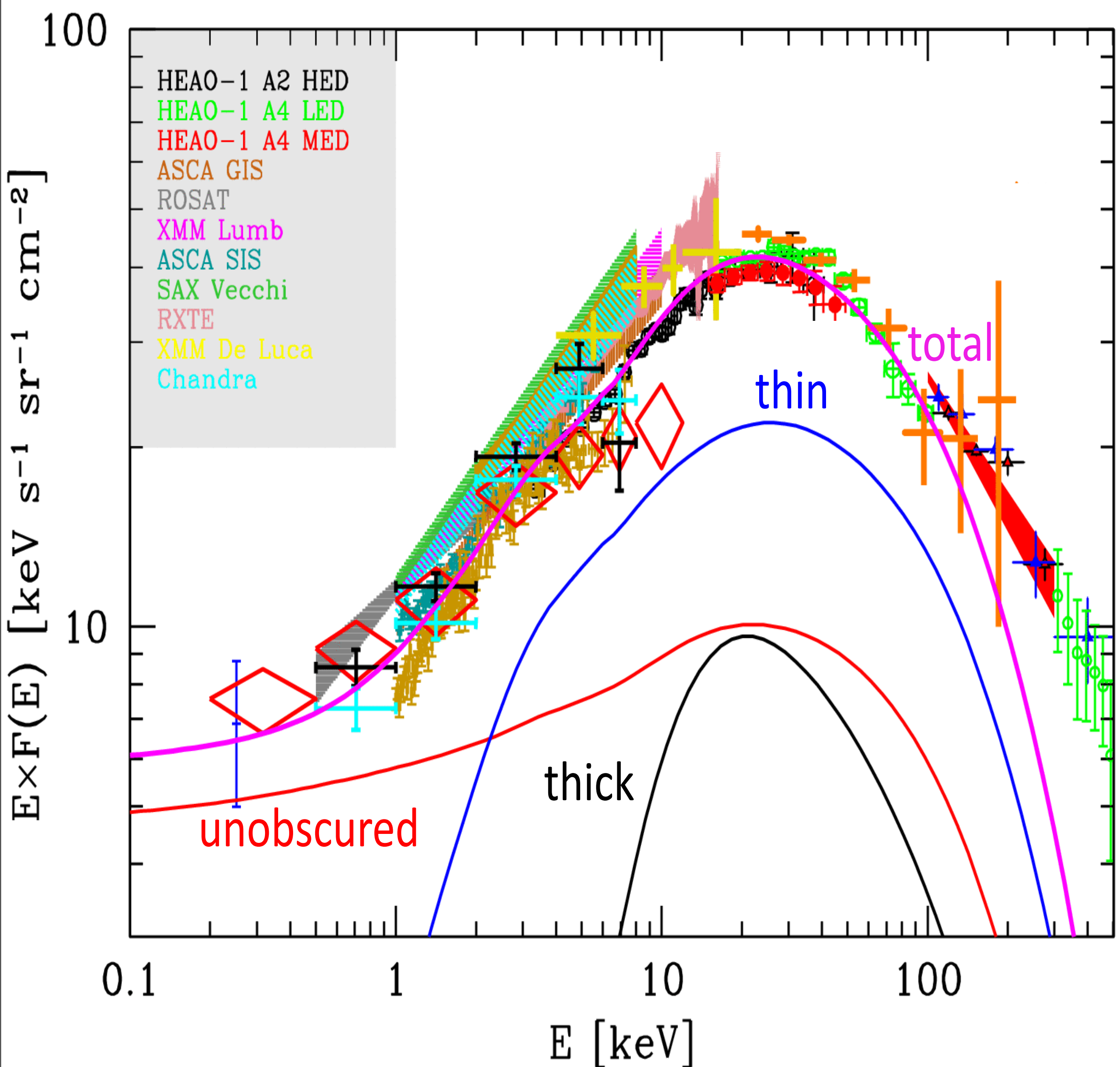
The brightest Sy 2 at 100 keV in the local Universe $N_H \sim 4 \times 10^{24}$ cm^{-2}

Rosetta Stone of CT AGN contributing to the peak of the XRB $N_H \sim 1.5 \times 10^{24}$ cm^{-2}

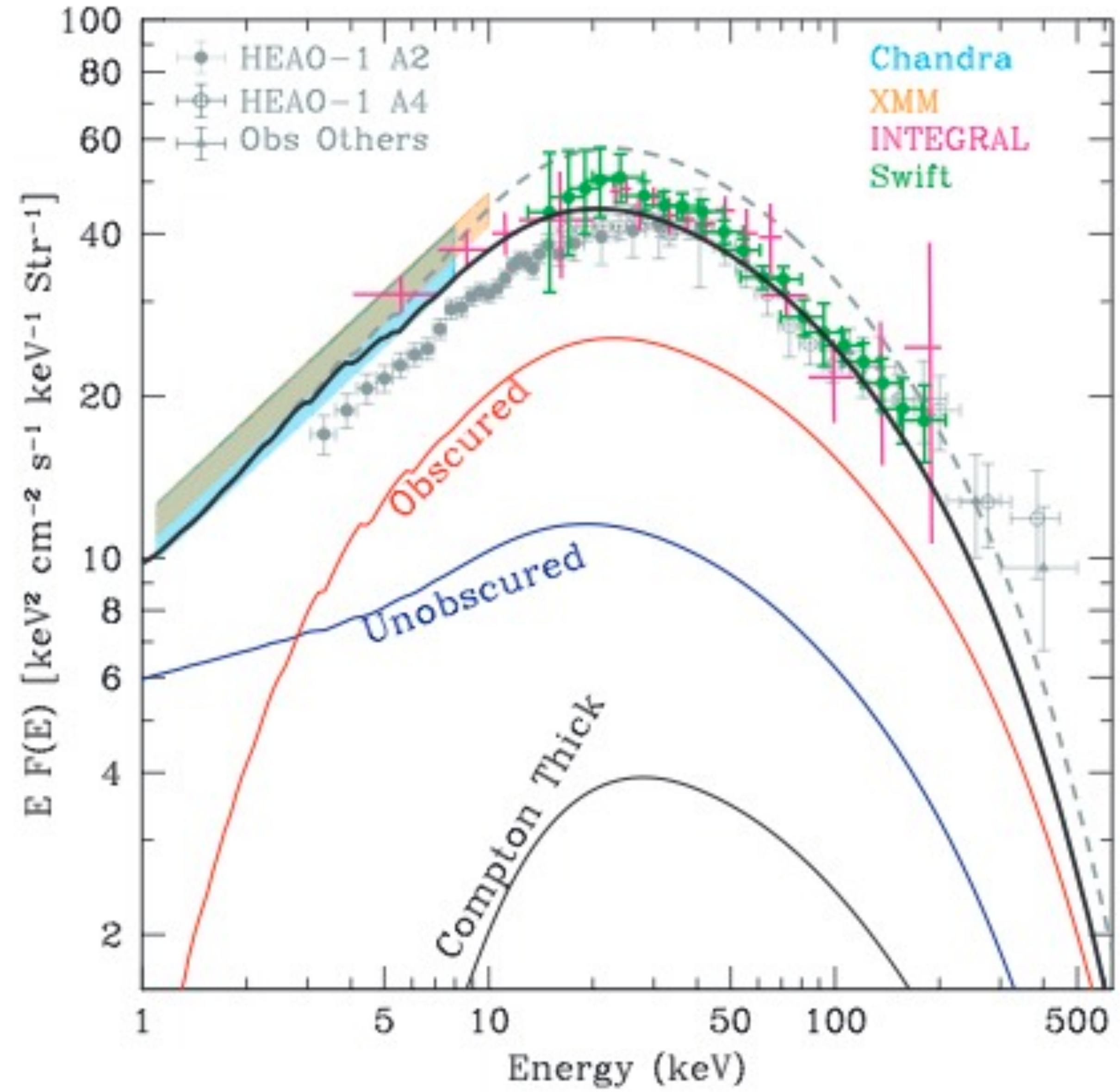
Abundant: up to 50% among [OIII] selected Seyferts

X-ray fration more debated (few up to a few tens %)

Population synthesis for XRB



Gilli, AC, Hasinger 2007 GCH07



Treister, Urry, Virani 2009 TUV09

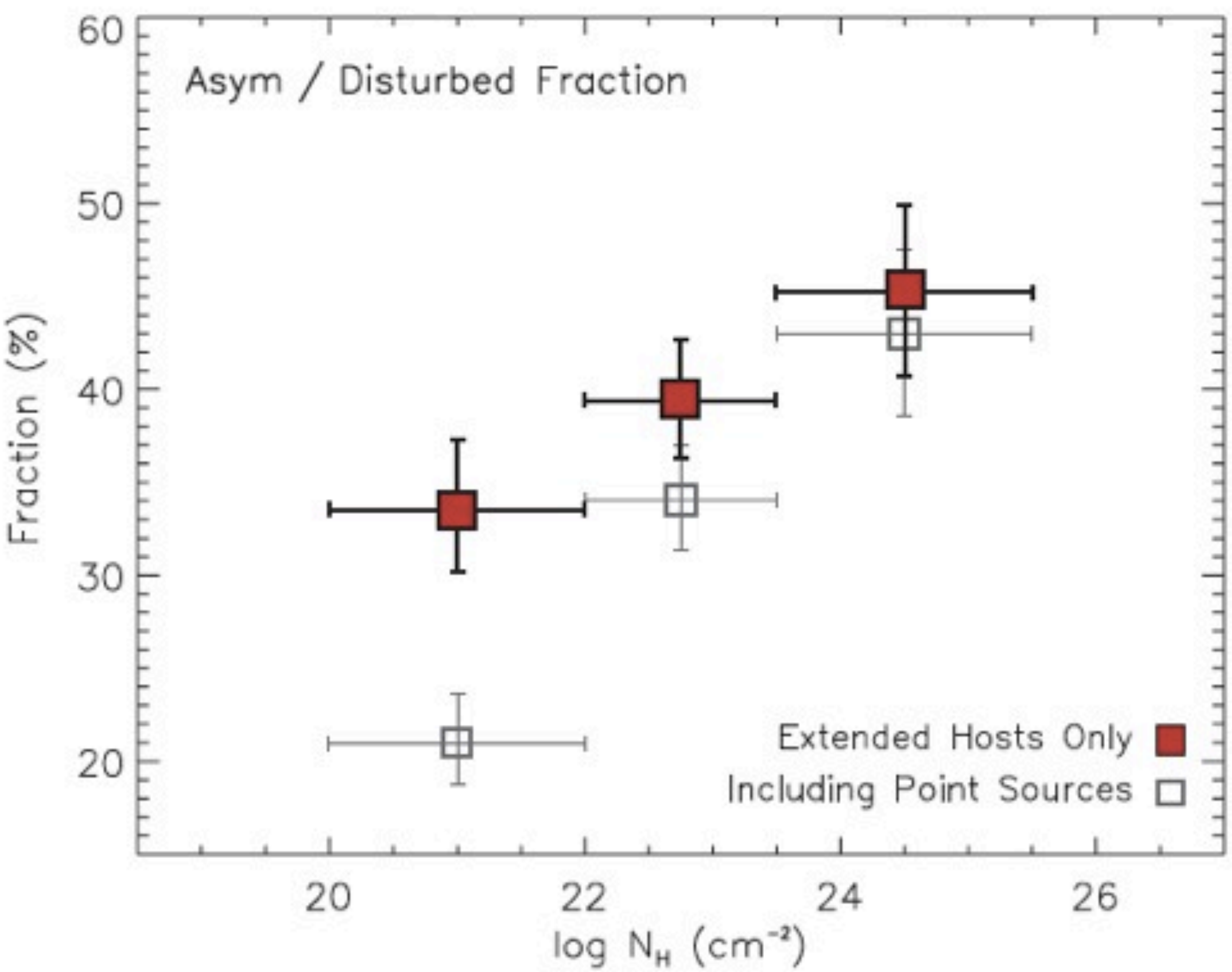
Based on luminosity dependent AGN unified scheme. Some 80% of accretion power is "mildly" obscured.

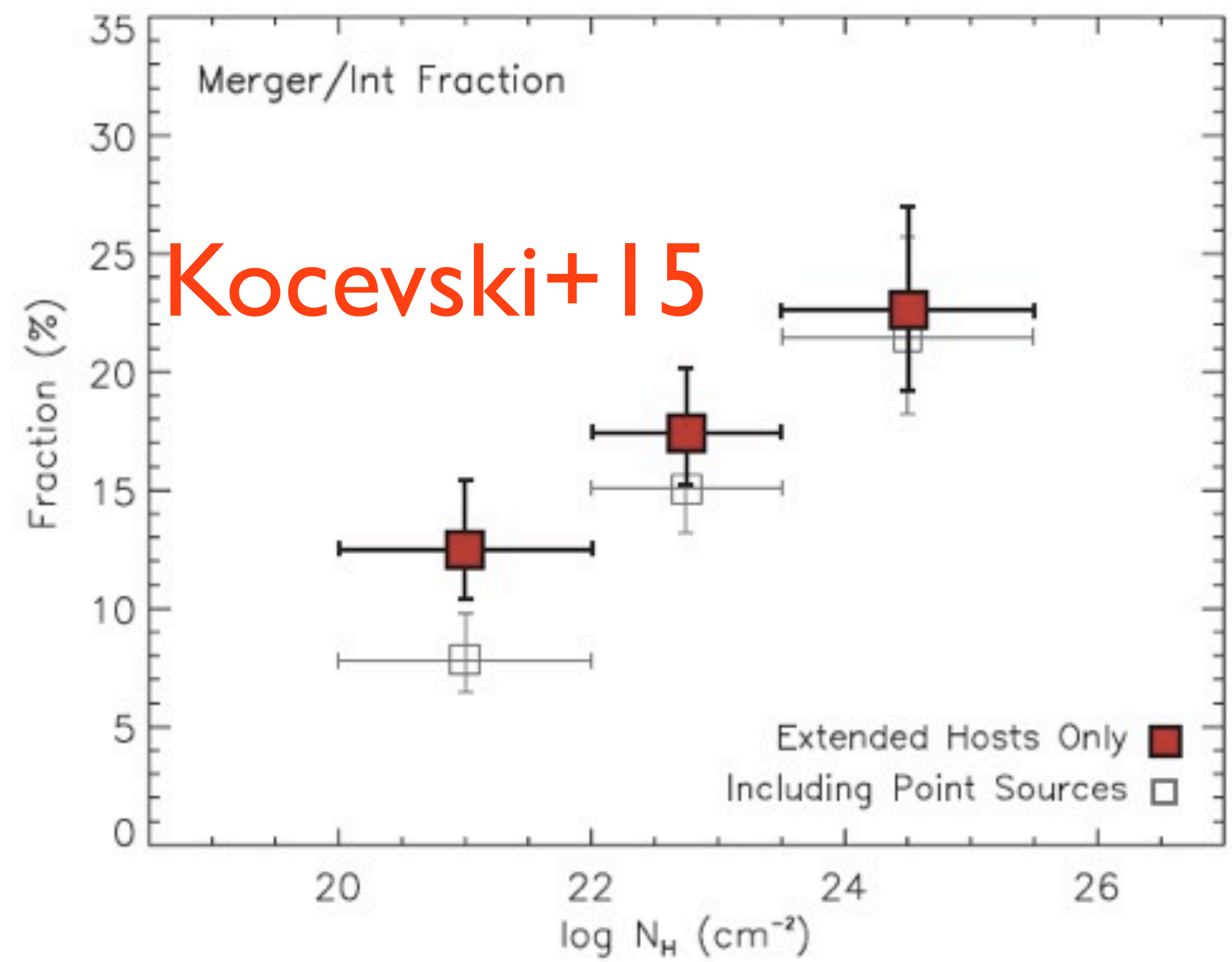
About 1/4 (GCH07) or ~10% (TUV09) are Compton thick.

The bulk of energy output is emitted at z ~ 1.

Obscured AGN at z ~ 1

In the evolutionary sequence obscuration is likely to cover a large angle (up to 4π) and correlates with host properties

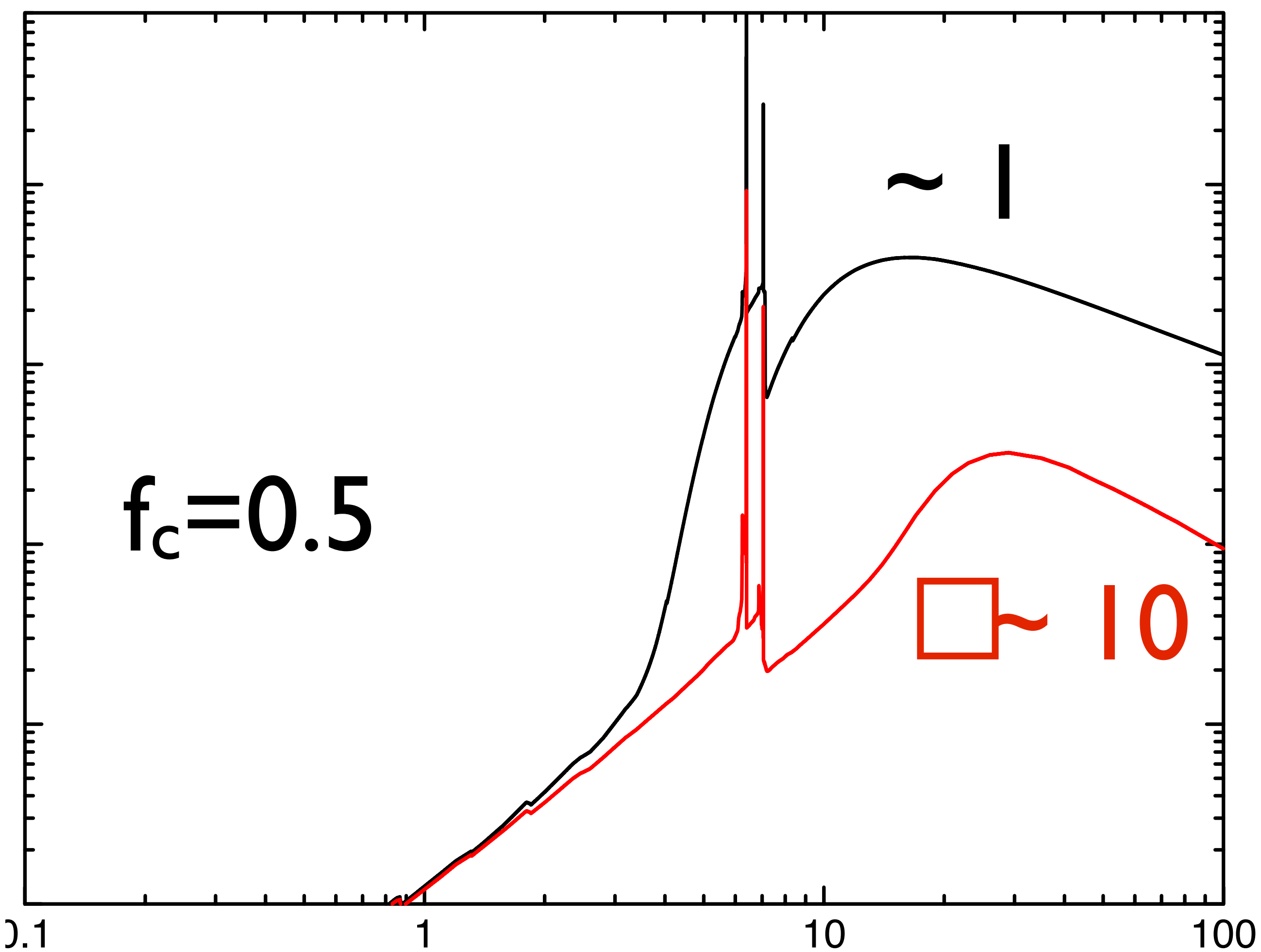




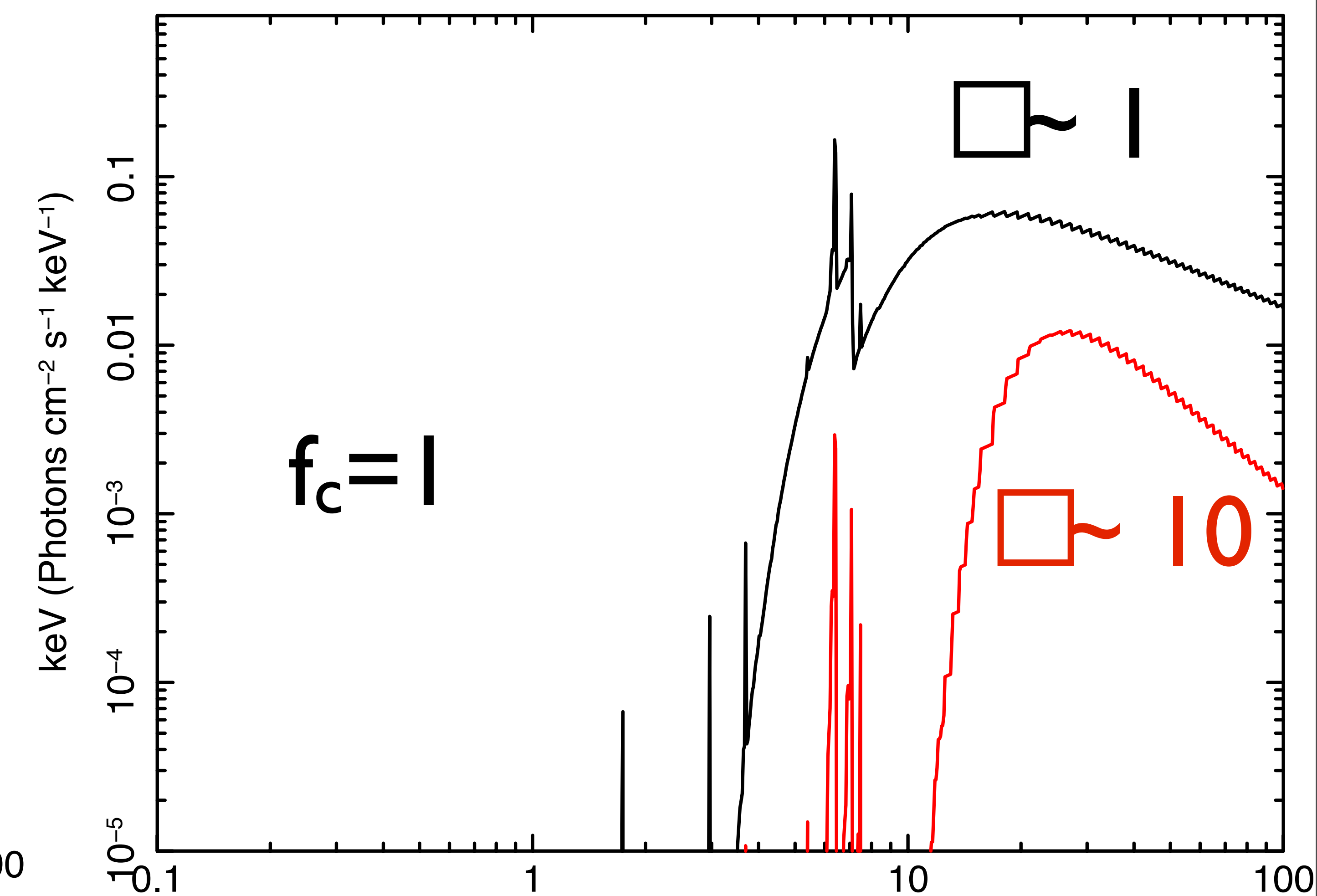
Increased merger/disturbed fraction (2.5-4σ) for increasing obscuration. Obscured AGN are preferentially hosted by late type galaxies relative to unobscured

Searching for CT AGN beyond the local Universe

Broad band (especially > 10 keV) sensitive X-ray spectroscopy represents the most efficient way to uncover CT AGN NuSTAR+XMM/Chandra



"Torus Model" Murphy&Yaqoob09

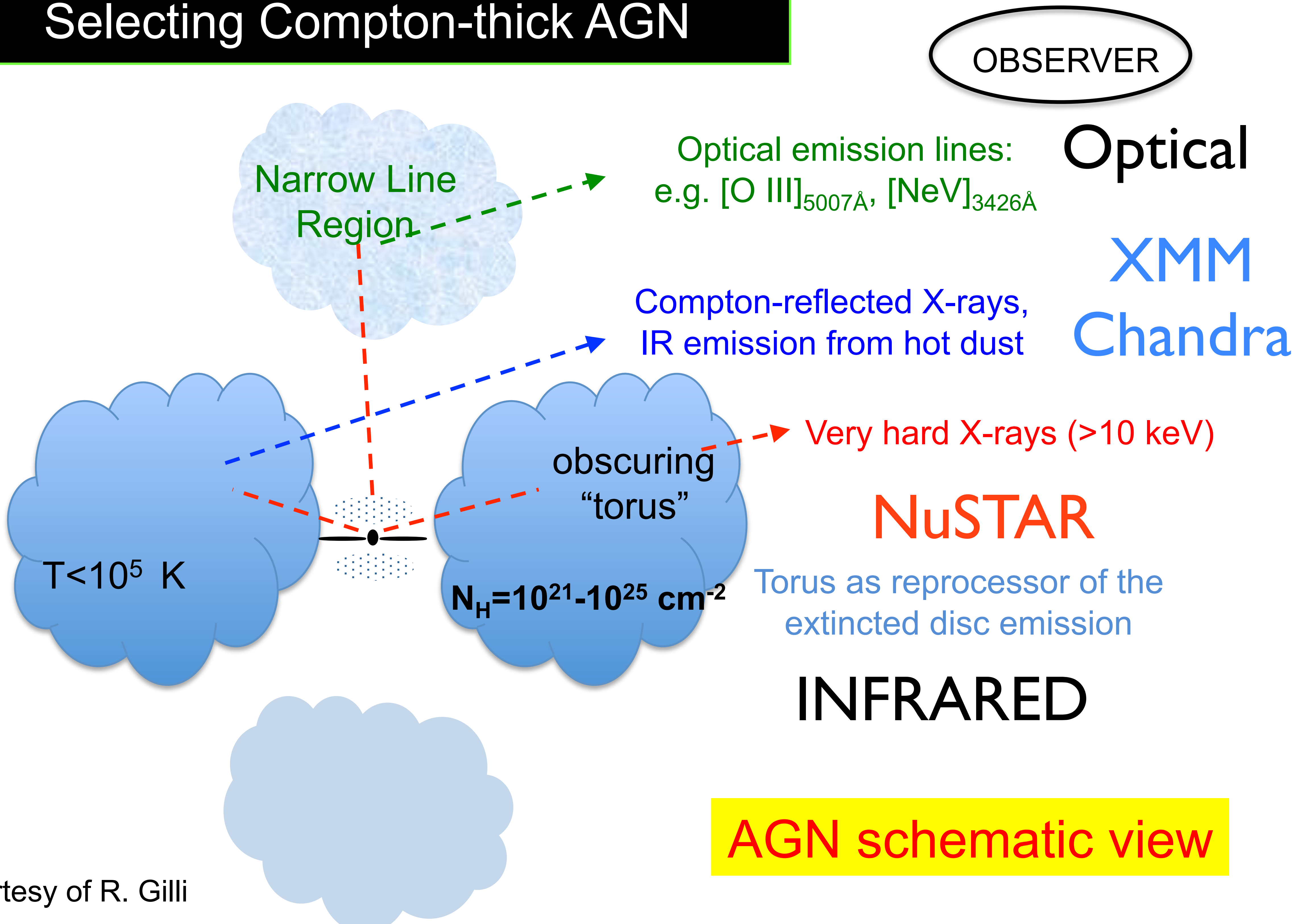


"Sphere" Brightman&Nandra11

Current picture is biased against obscuration especially beyond the local Universe and at both low and high luminosities.

Multiwavelength approach

Selecting Compton-thick AGN



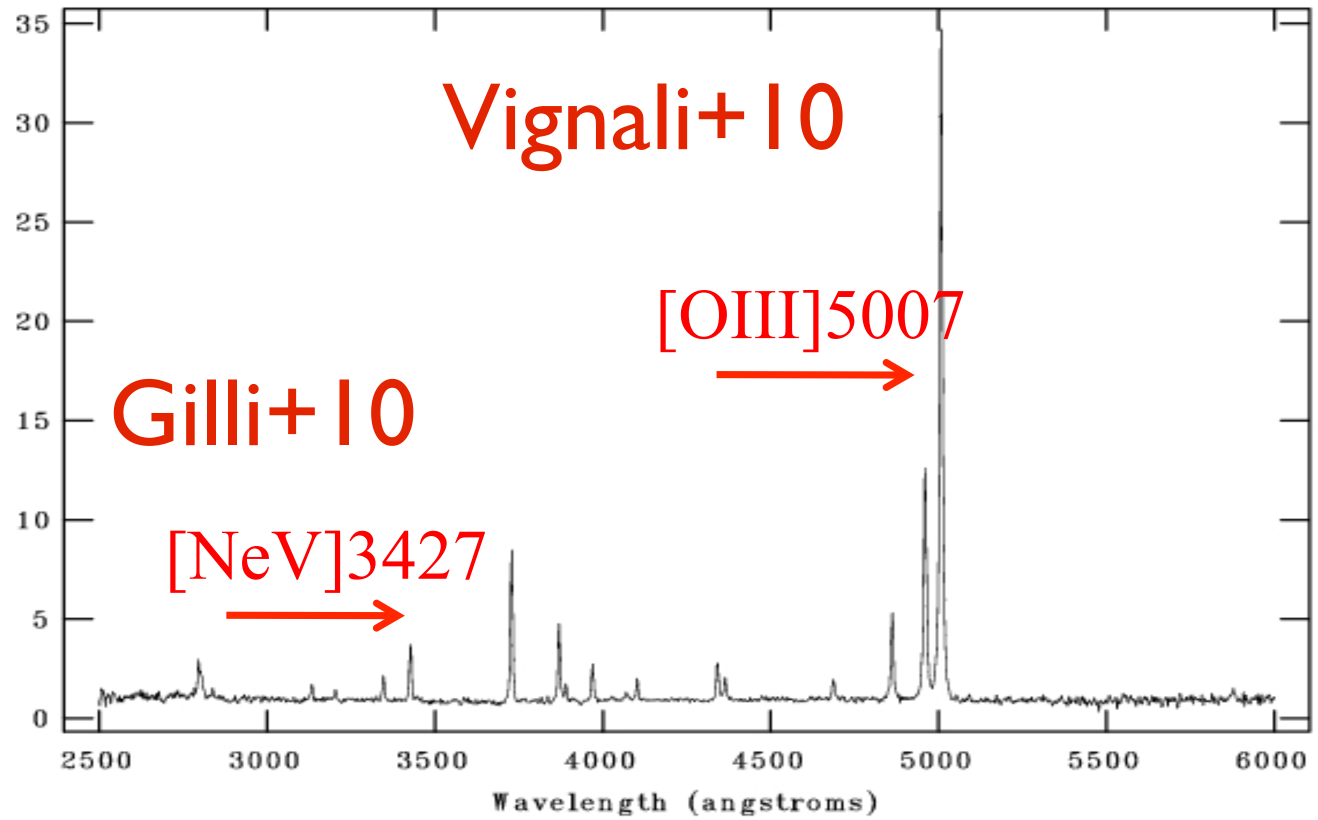
AGN schematic view

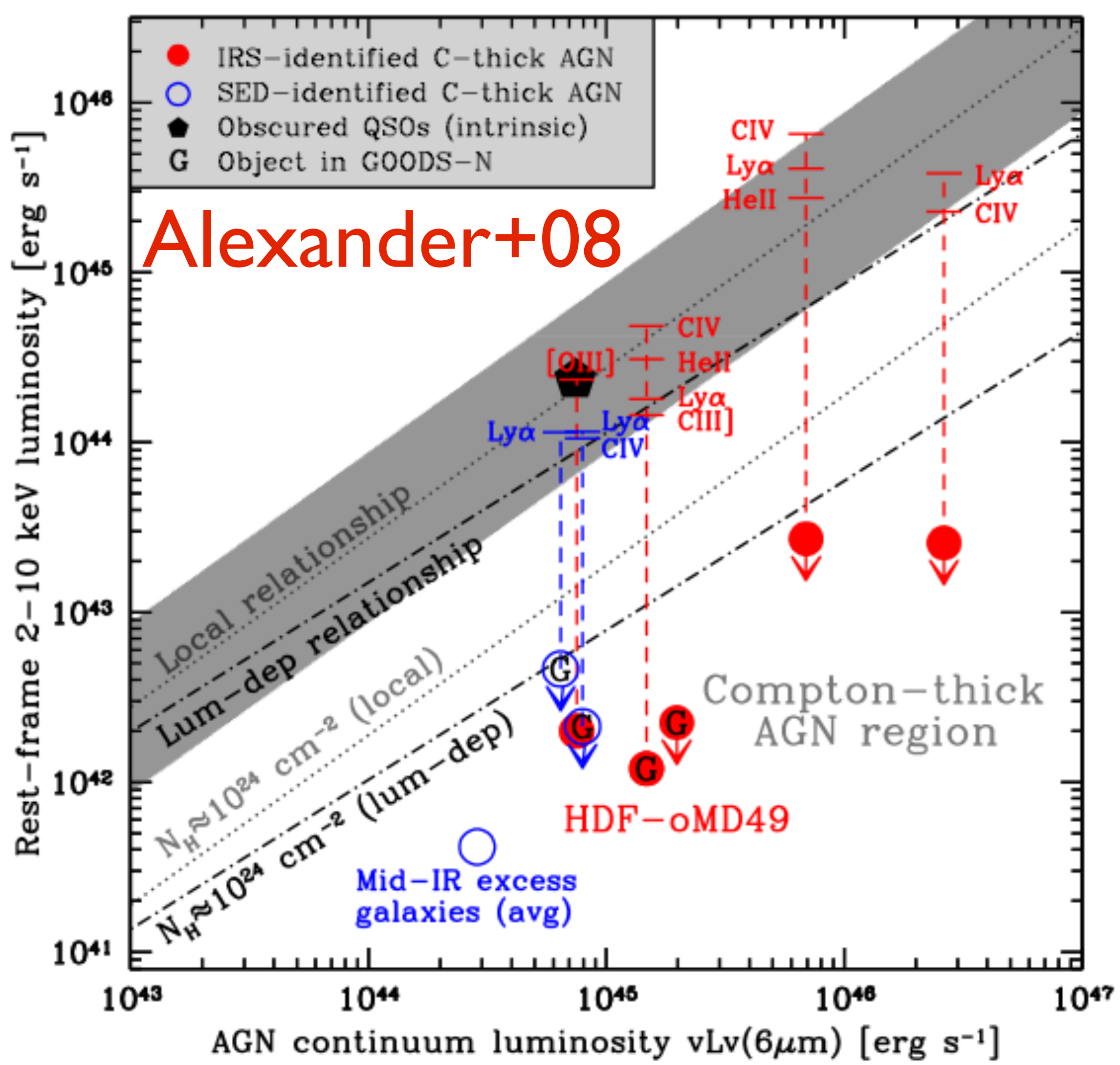
Courtesy of R. Gilli

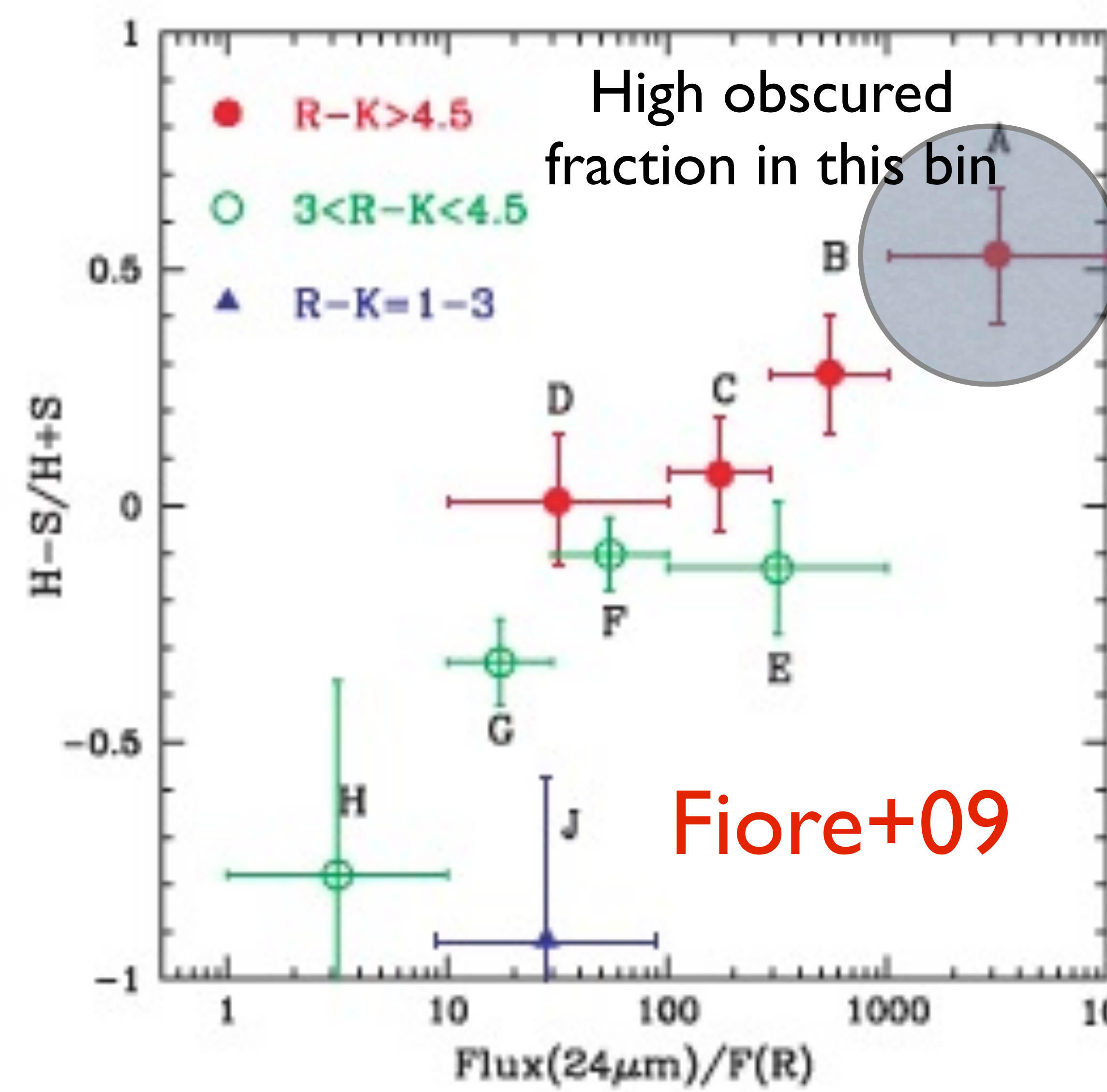
The bottom line is to compare line and/or optical/IR continuum luminosities to X-ray observations

Del Moro + 15, Stern+14,15

Weakness - Are really AGN?







Compton thick AGN

Current surveys are still not able to measure the geometry of obscuring material and its evolution beyond the local Universe. Current Chandra/XMM/NuSTAR/SwiftBAT/INTEGRAL data suggest that X-ray surveys are sampling the tau~1 population

Looking forward for further NuSTAR surveys and combined XMM-Chandra-Suzaku-NuSTAR spectral analysis to infer the geometry of the CT obscuring gas and break the degeneracies

A sizable population of highly obscured and CT AGN over a range of redshifts (say 0.5-2), is inferred from INDIRECT methods (optical/MIR line and continuum vs X-ray). They add up to the X-ray detected ones and may be highly covered highly absorbed or both (linked to the "evolutionary sequence"?)

How many of them? Too many?

SMBH Mass Density

$$\rho_\bullet c^2 = \frac{1-\epsilon}{\epsilon} \times U_T = \frac{1-\epsilon}{\epsilon} \times \langle k_{bol} \rangle U_X$$

ε accretion efficiency

K_{bol} X-ray Bolometric correction

$$U_T = \int dz \frac{dt}{dz} \int L\phi(L,z) dL$$

U_T Comoving Bolometric energy density

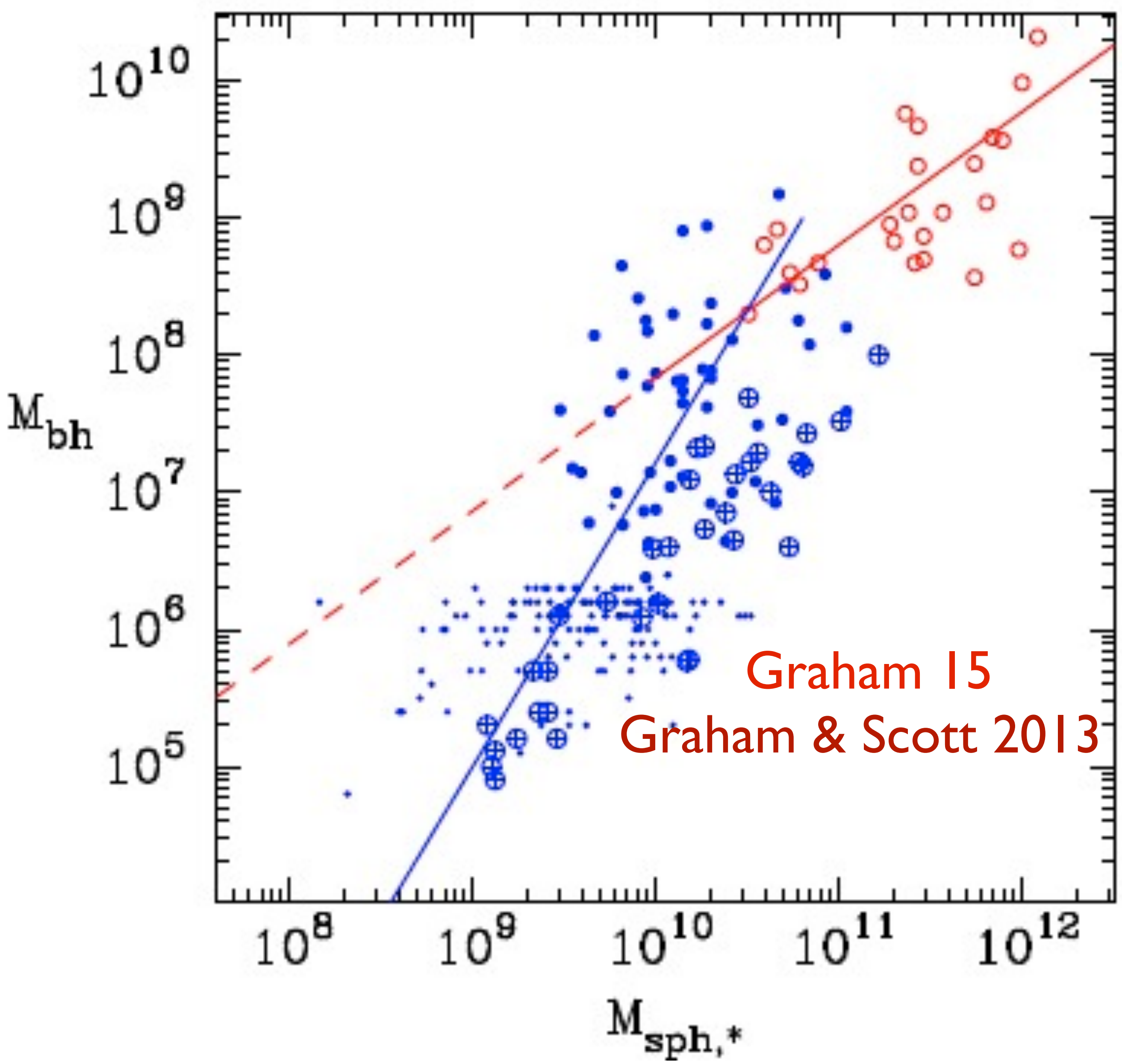
$$U_T = \langle k_{bol} \rangle \frac{4\pi I_0}{c} (1 + \langle z \rangle)$$

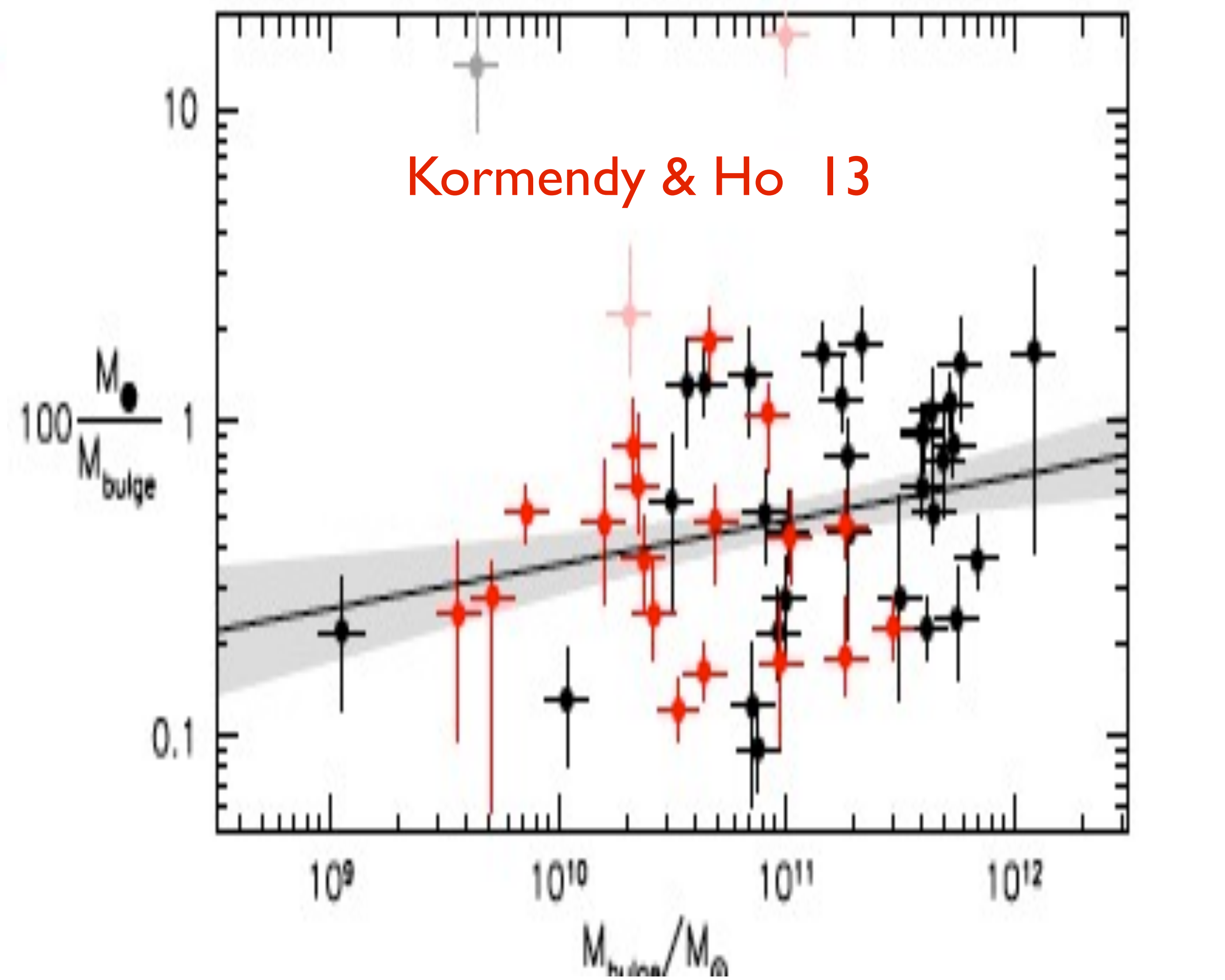
I_0 XRB energy density

Assume XLF evolution, bolometric correction, ...
account for Compton thick AGN or the XRB intensity at its peak.

Require consistency with the local value from scaling relations ($M_\bullet$-M_{Bulge}-σ) get average efficiency or constrain parameters entering in the above equations.

Black Holes and Bulges





BH-to Bulge ~ 0.5% cfr 0.1-0.2% of previous relations i.e. Sani+11, Marconi & Hunt 03

1) omit pseudobulges
2) omit mergers in progress
3) omit galaxies with BH mass based on ionized gas dynamics

The "low 0.1-0.2% " normalization of the scaling relation is consistent with current knowledge of AGN evolution, including CT fraction from XRB models, and "returns" 0.1 efficiency (Marconi +04)

$$\rho_\bullet c^2 = \langle k_{bol} \rangle \frac{1-\epsilon}{\epsilon} U_{xo} (1 + \sum_i R_{ob})$$

To fit more mass you may decrease the average accretion efficiency (ADAF like, i.e. Novak 2013)

$$\rho_\bullet = \rho_{\rm S} - \rho_{\rm GW} + \int (\dot{\rho}_{UO} + \dot{\rho}_{\rm OB} + \dot{\rho}_{\rm CT} + \dot{\rho}_{\rm RI})\, dt$$

Could heavily obscured, Compton Thick AGN make the job?

Accretion efficiency is not a free parameter, but is assumed to be 0.1. The bolometric correction is also assumed to be consistent with the recent observational framework (i.e. Lusso+12)

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(with $\rho_{\rm S}$ and $\rho_{\rm GW}$ struck through)

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(The terms $\rho_{\rm S}$, $\rho_{\rm GW}$ and $\dot\rho_{\rm RI}$ are struck through in red.)

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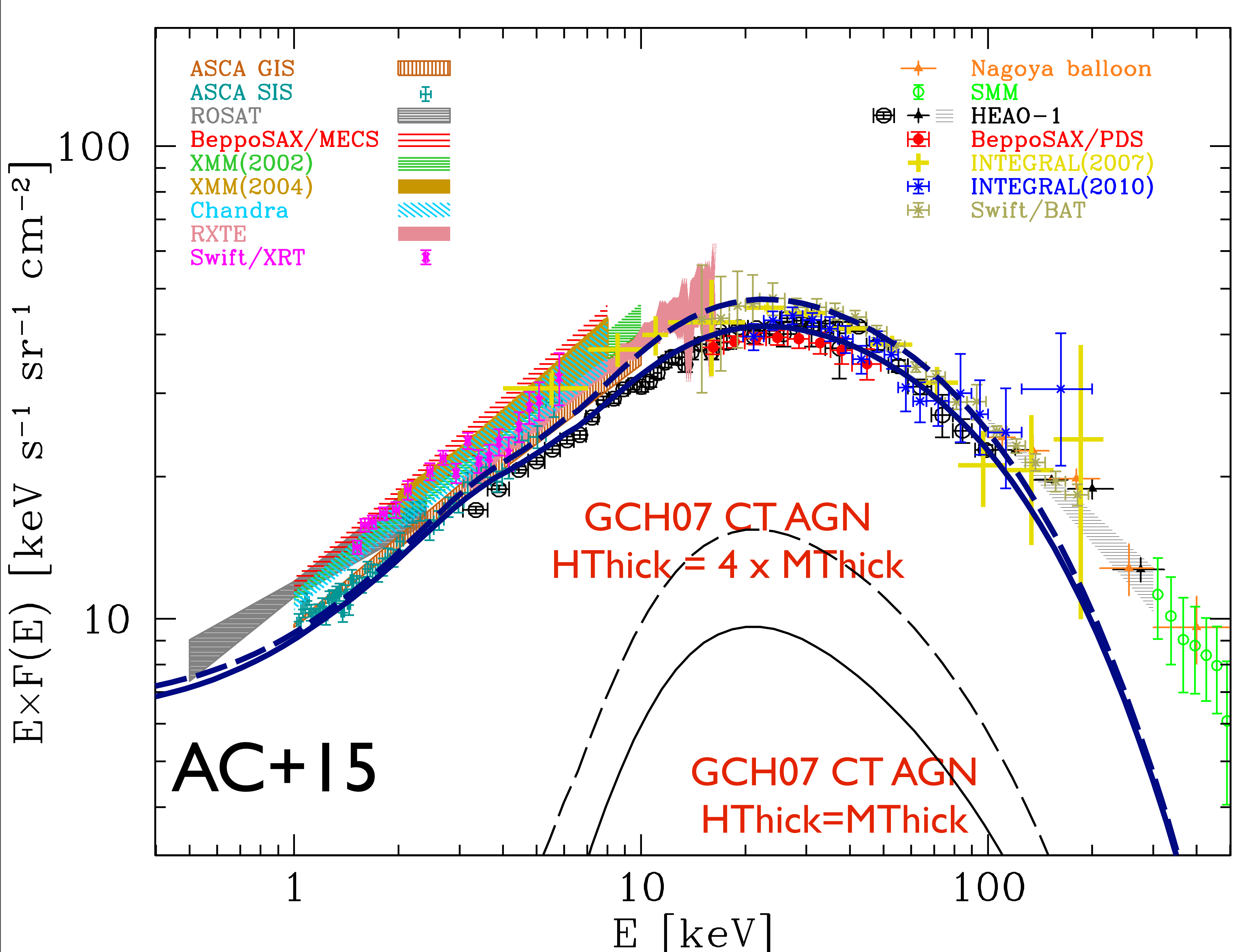
If the “mass increase” is a factor 2 (on the lower side of the revised value) and consistent with that adopted in Marconi+04,06

$$2\rho_\bullet c^2 = \langle k_{bol}\rangle U_o \frac{1-\epsilon}{\epsilon}(1+\sum_i R_{obs} + R_{new})$$

In GCH07 the luminosity averaged ratio between Thick, Thin, unobscured is 3:3:1 (Thick equally splitted between Hthick and Mthick)

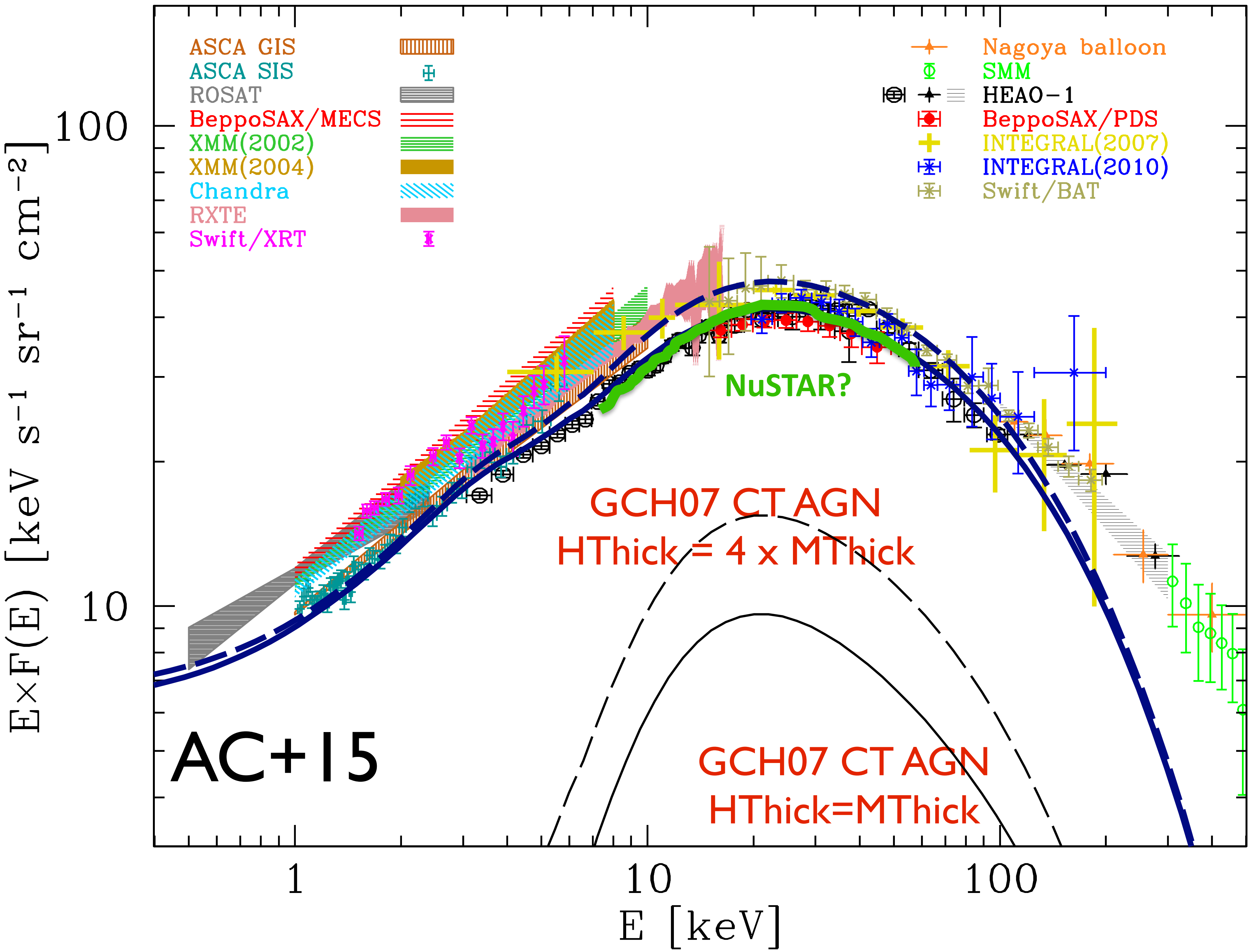
$$R_{new} = (1+\Sigma R_{obs}) = 7$$

For each SMBH contributing to the XRB (unobscured, thin & thick) there is an X-ray silent object contributing to the mass density only



You may "play" with current uncertainties on the intensity of XRB peak

Still a sizable fraction (~20%) of "all" SMBH could be X-ray silent



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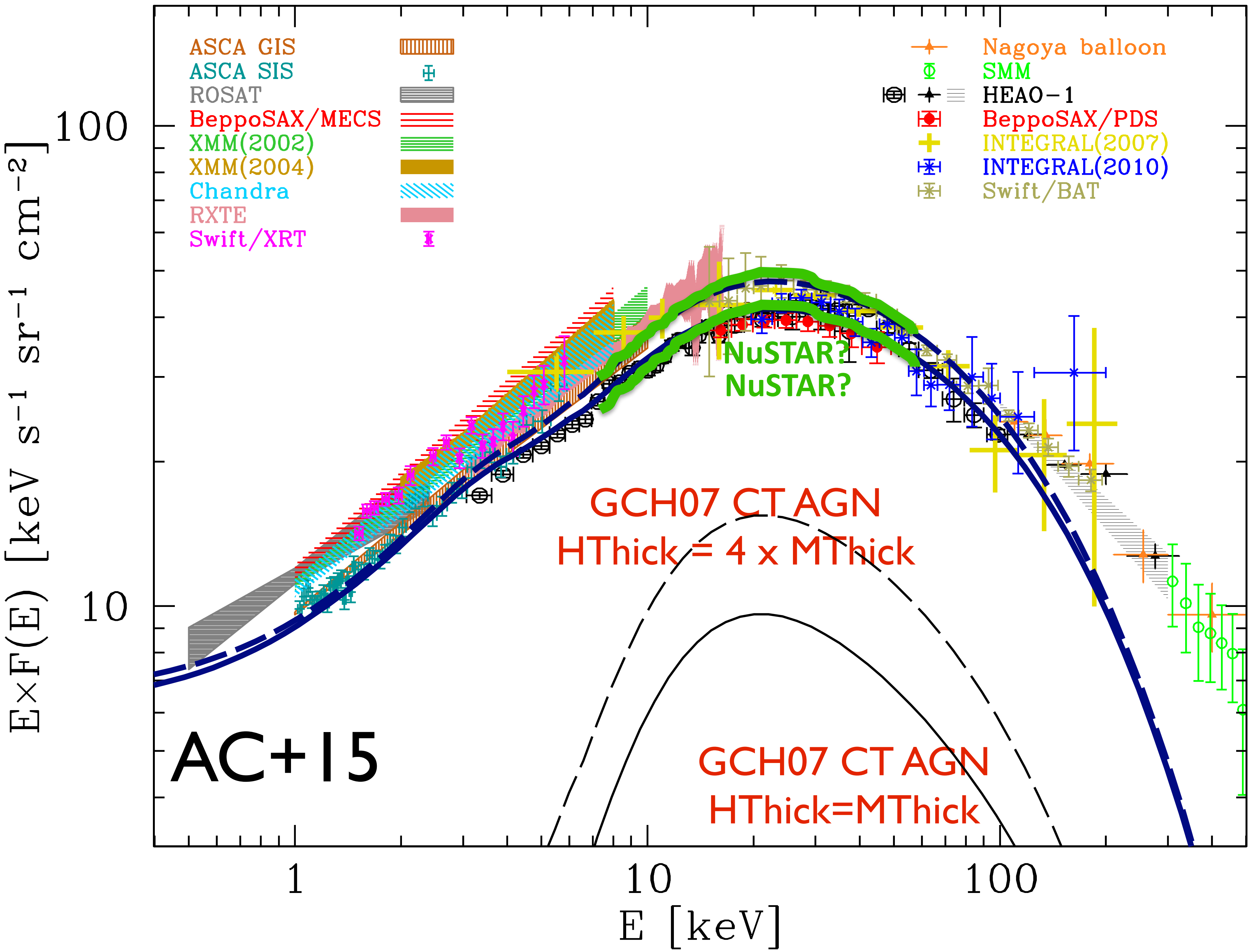

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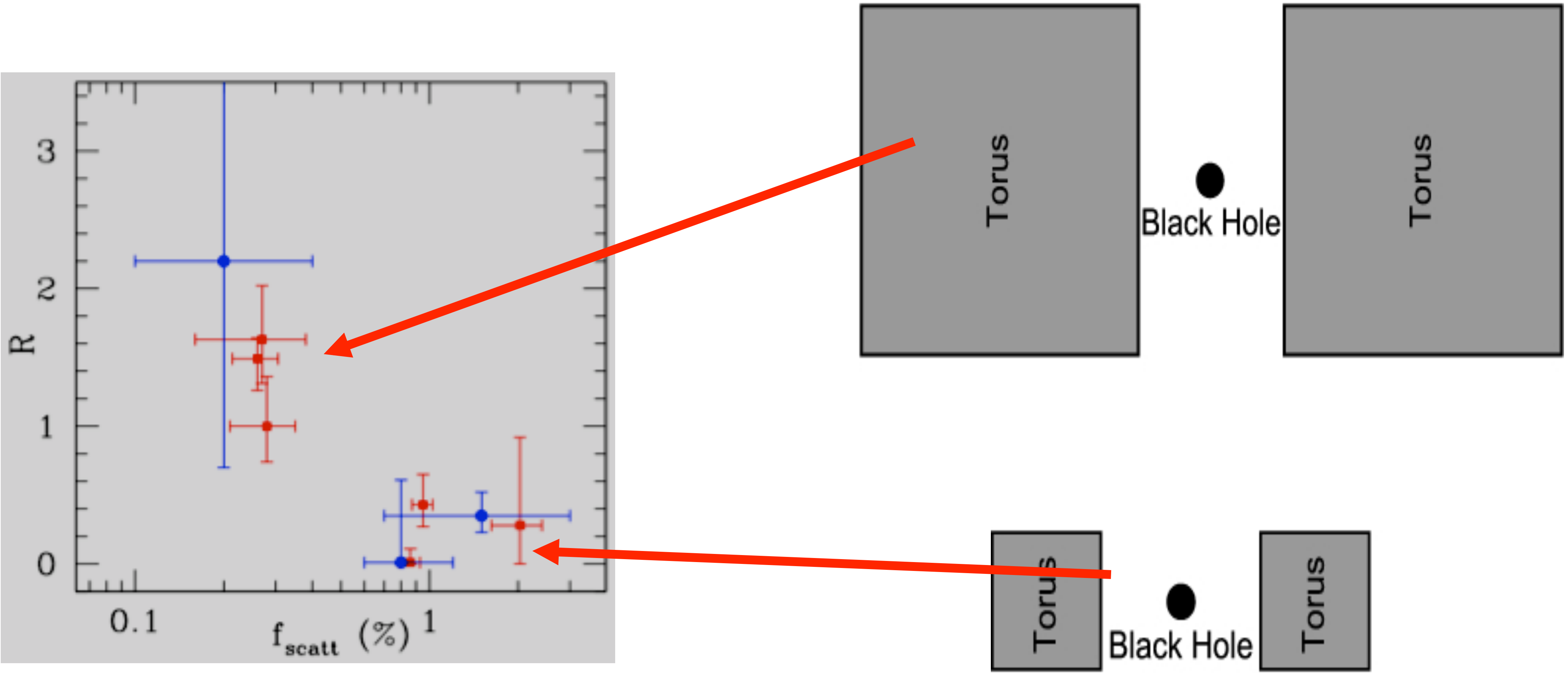
A new class of obscured AGN?

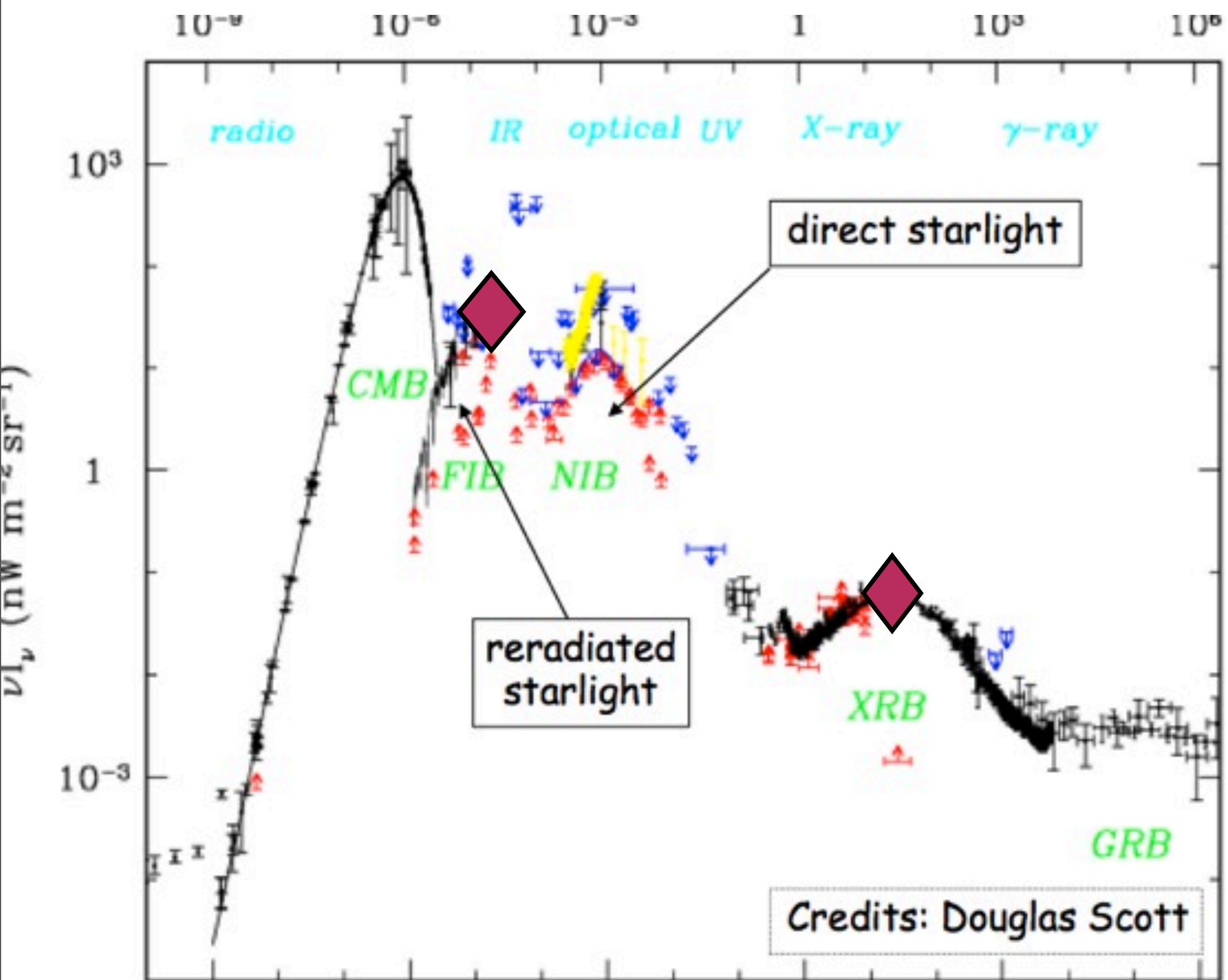


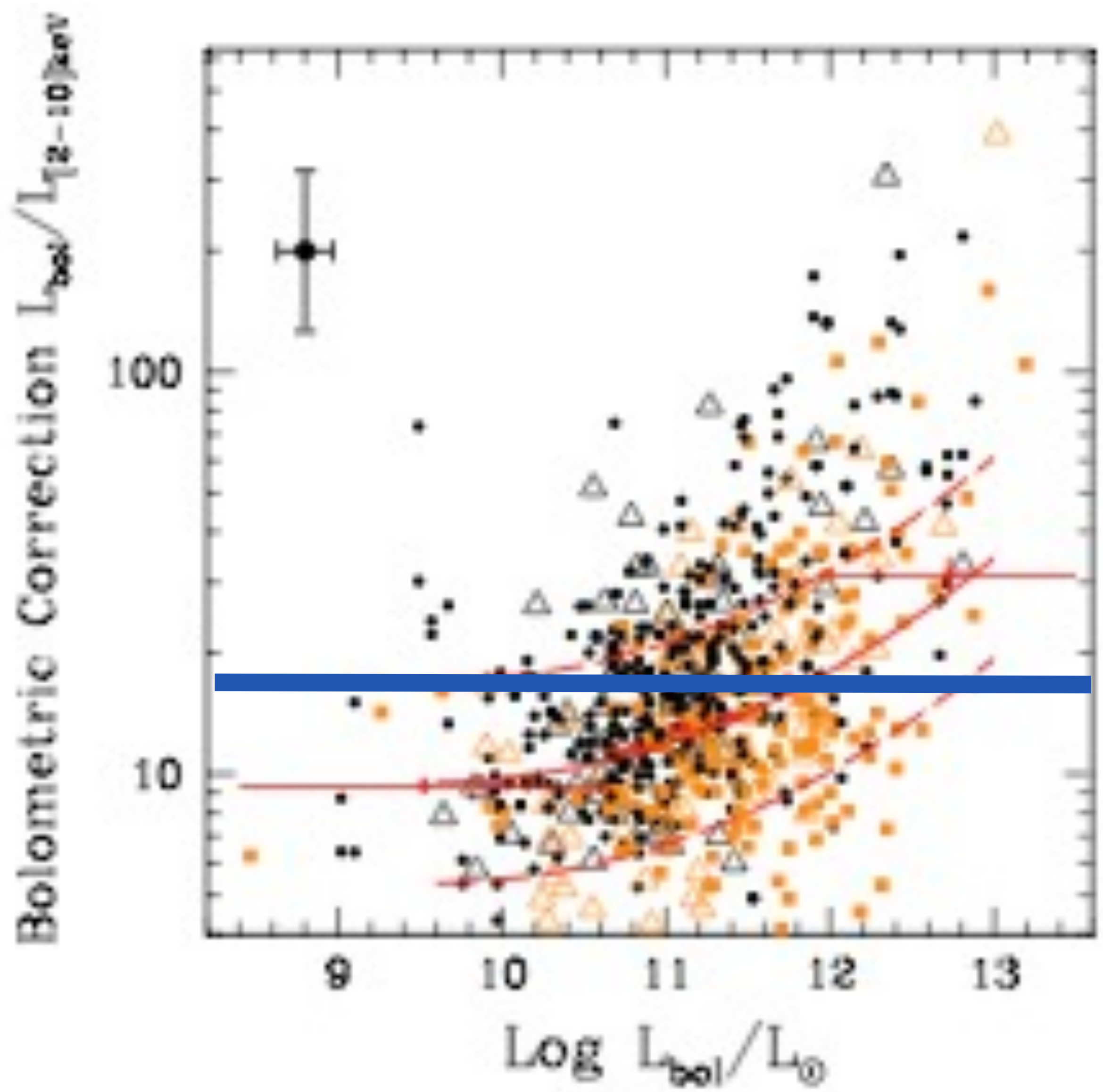
New Type AGN are seen almost face-on through a geometrically thick torus w/ small opening angle

Large population of heavily Compton Thick ($N_H \sim 10^{25}$) missed by present hard (> 10 keV) surveys !

Ueda+07
Eguchi+09
AC+10
Brightman+14

IR background



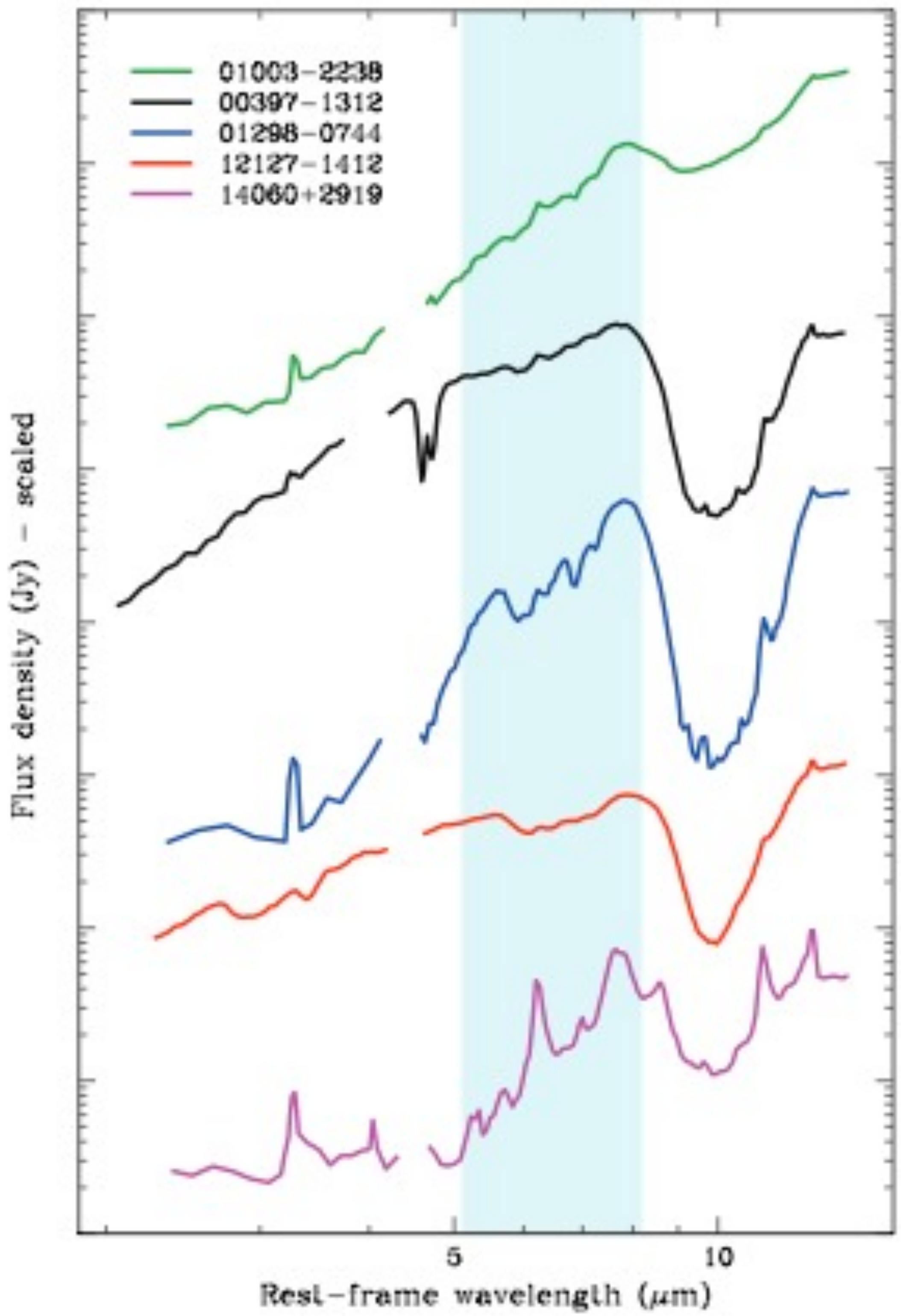


FIRB ~ 300 XRB

Average Bolometric correction for obscured AGN (Lusso+12)

Assuming k_{BOL} ~ 20 and twice more SMBH than needed for the XRB → *some 15% of the FIRB could be due to AGN*

ULIRG ?



Nardini & Risaliti 2011

Near IR spectroscopy of ULRIG AGN. Lack of PAH features, no SB, but buried nuclei.
X-ray observations: weak or undetected with XMM

"The upper limits on the reflected flux are an order of magnitude lower than the usual reflection efficiency observed in type 2 active galaxies, suggesting an almost complete covering."

ALMA observations of Arp220
$N_H \sim 0.6-1.8 \times 10^{25}\ cm^{-2}$ (Wilson+14)

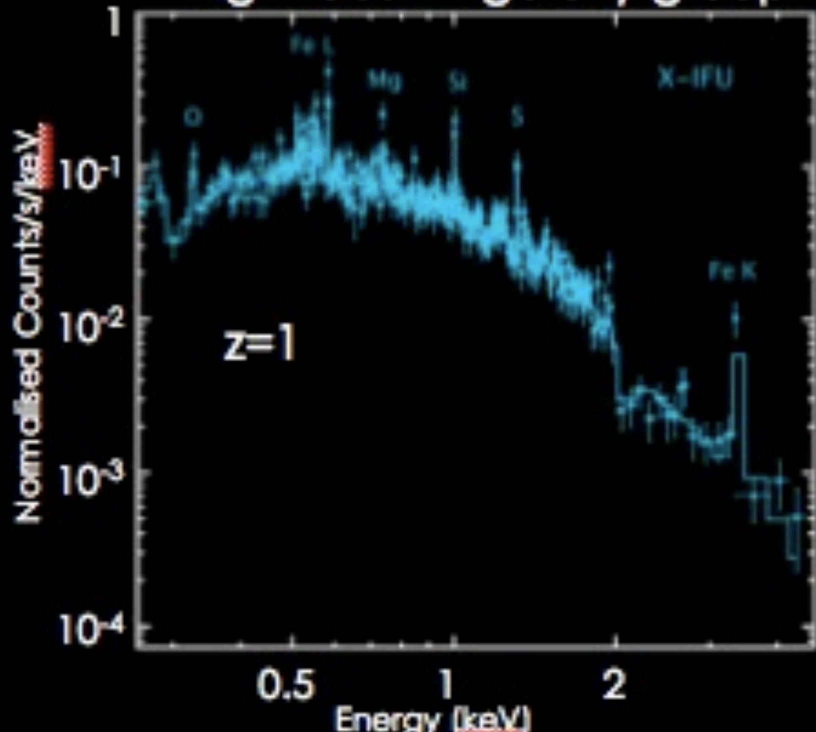
Intriguing example in Francesca Pozzi talk

Future Perspectives

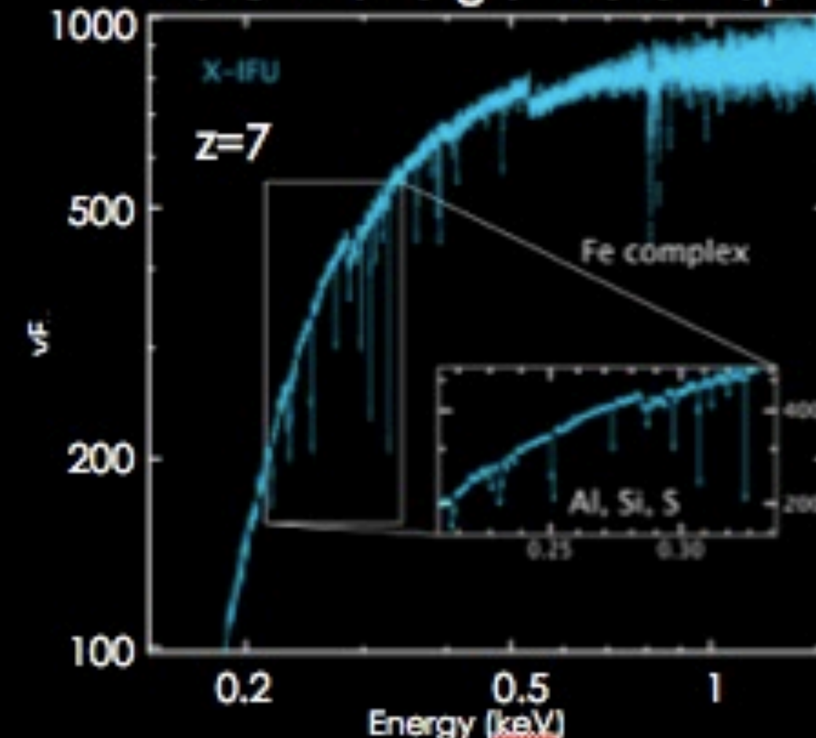
- X-ray follow up of "suspected" deeply buried optically/MIR/NIR/Line selected objects with Chandra/XMM/NuSTAR and eventually ATHENA
- MIR spectroscopy with SPICA of both long wavelength selected and X-ray selected
- ATHENA & SPICA synergy

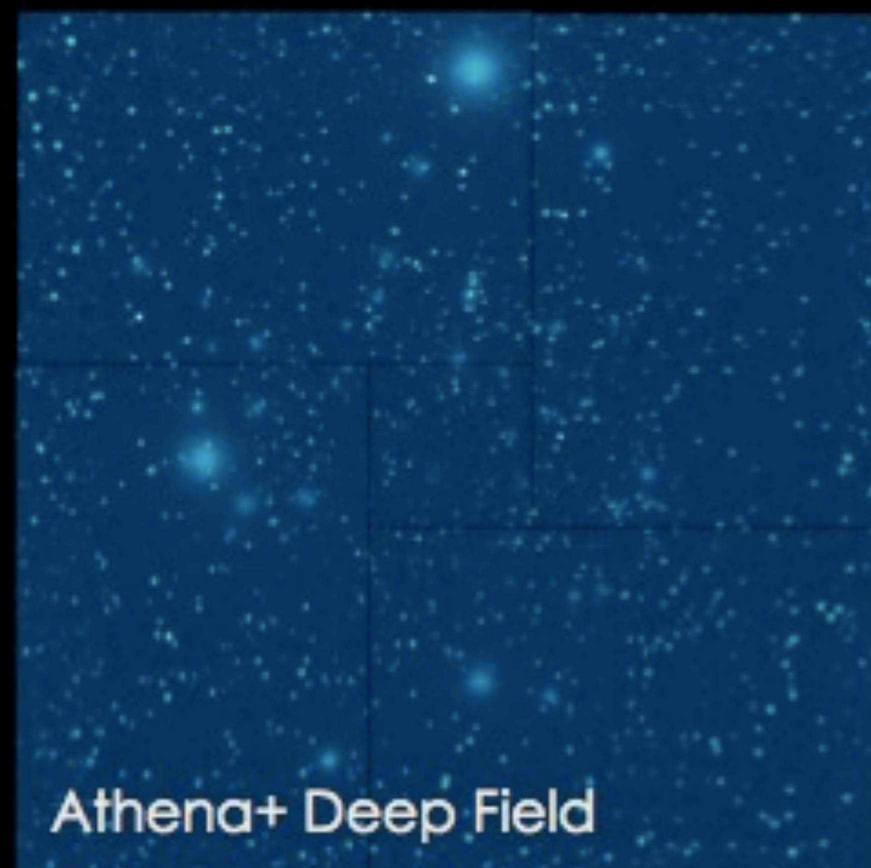
Athena+
The first Deep Universe X-ray Observatory

High redshift galaxy group

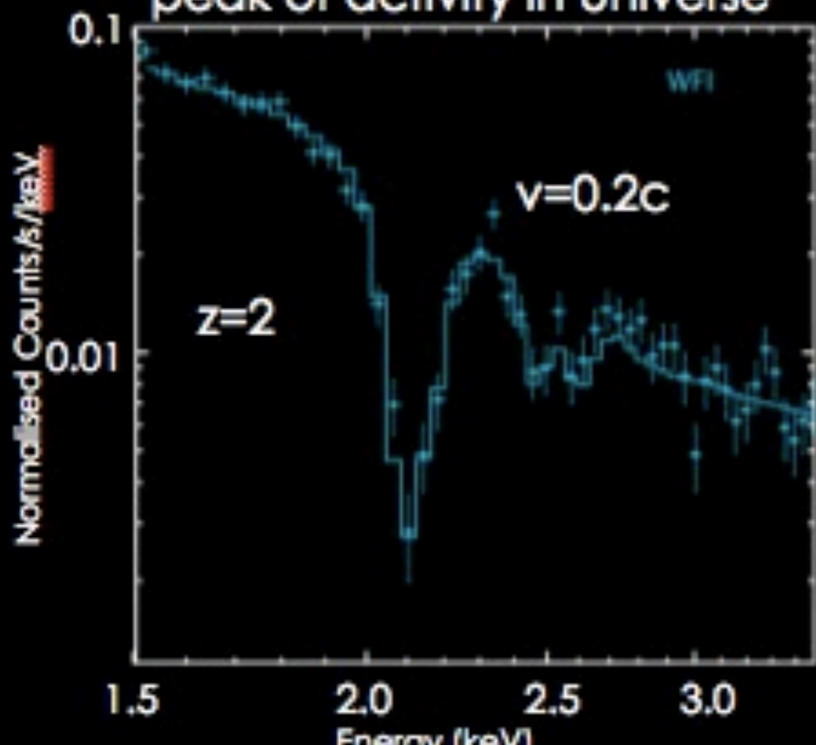


Primordial stellar populations via GRB afterglow follow up



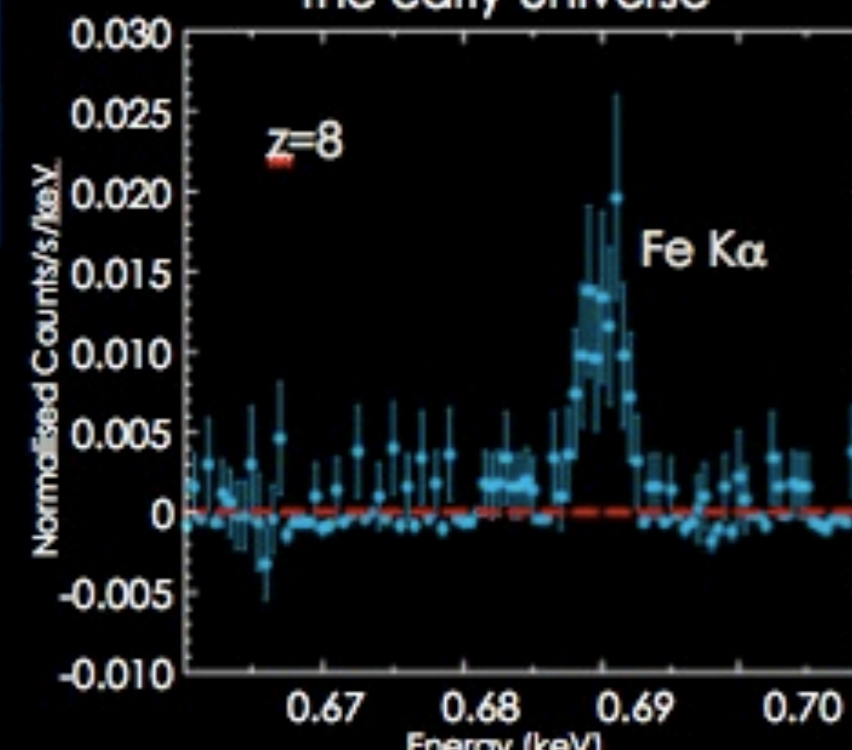


Black hole feedback at peak of activity in Universe



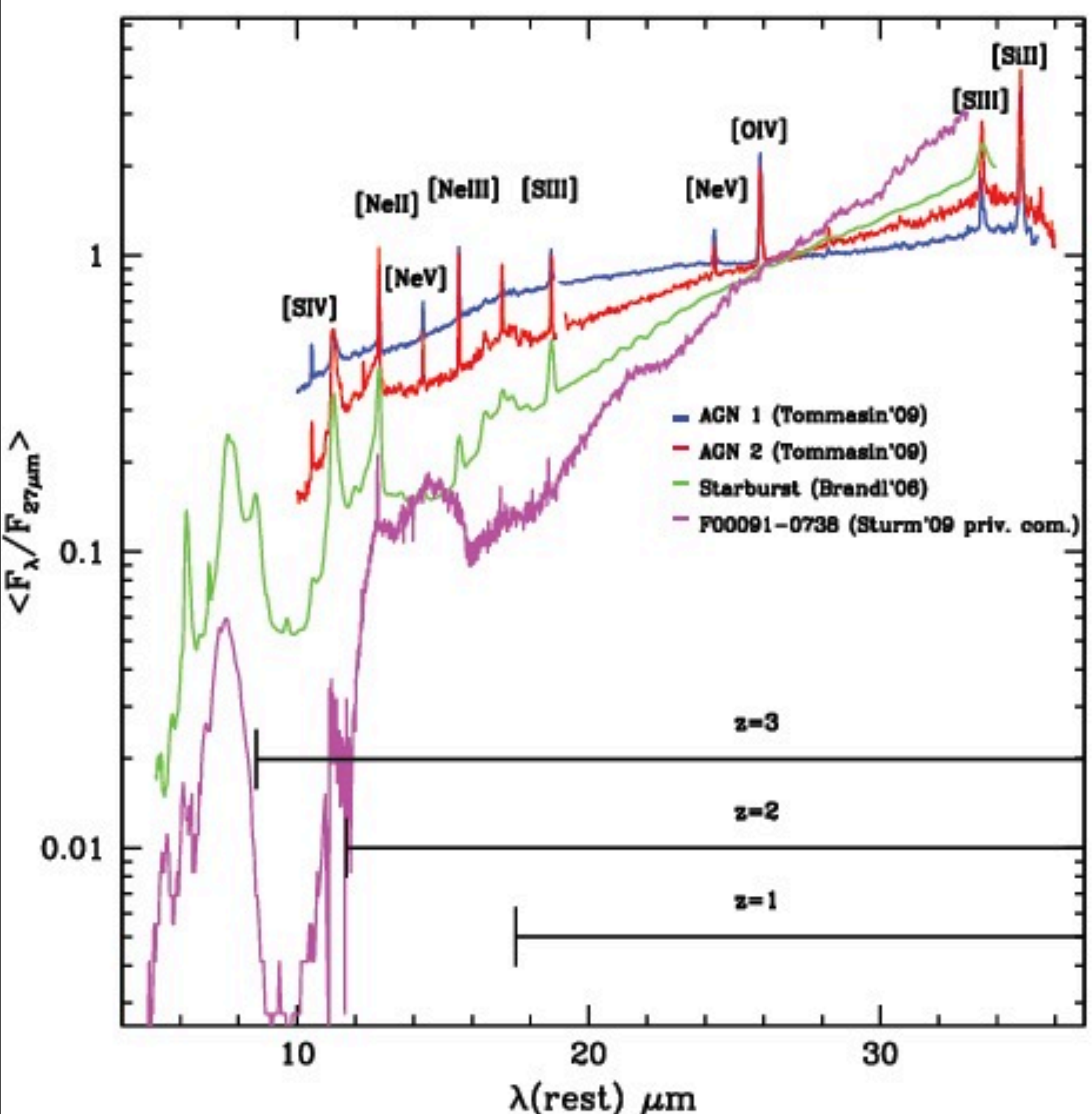
Nandra, Barret, Barcons, Fabian, den Herder, Piro, Watson et al. 2013 arXiv 1306.2307

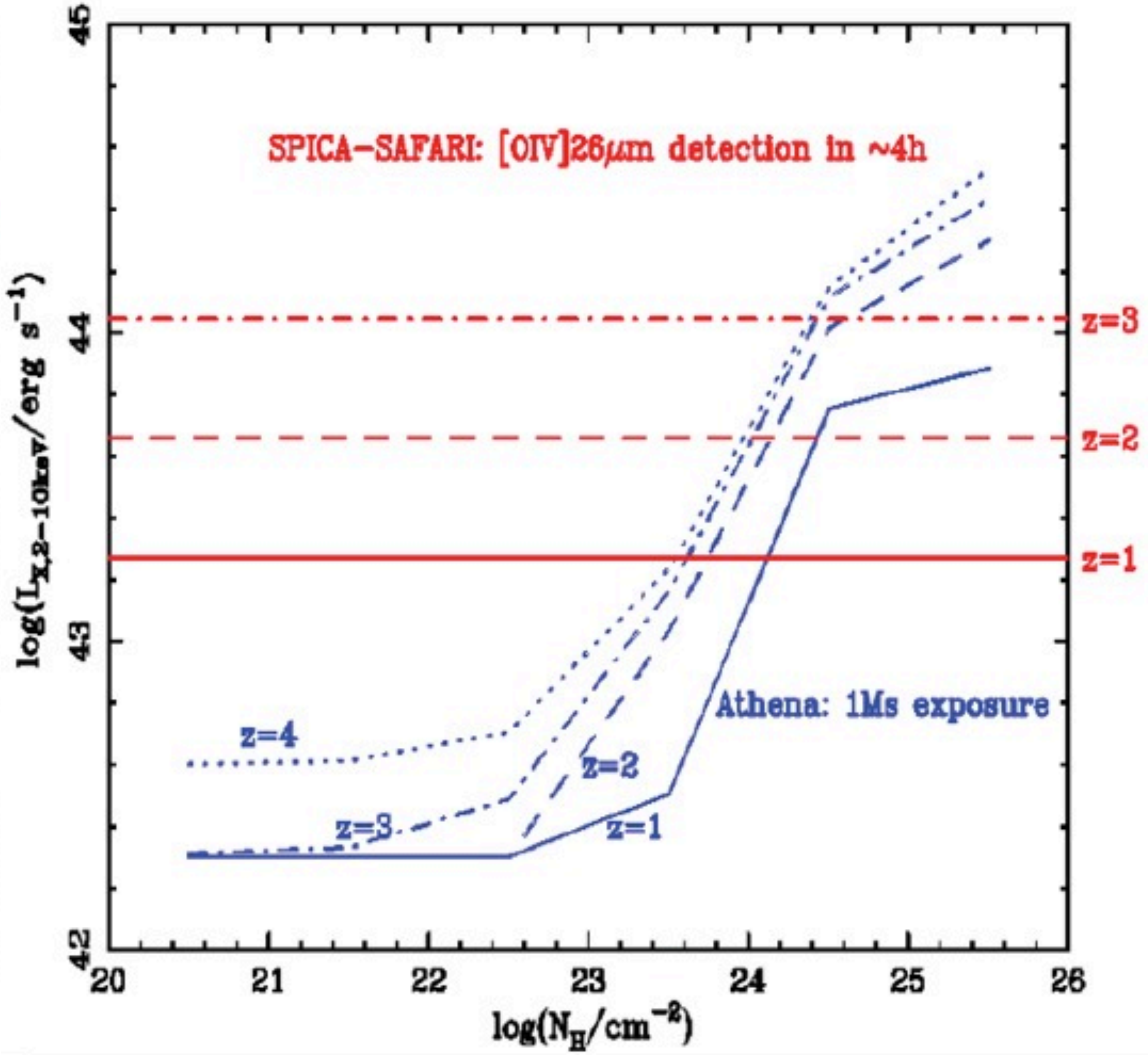
Obscured black hole in the early Universe



MIR Spectroscopy

Deeply buried CT AGN may be recognized thanks to MIR spectroscopy down to relatively low luminosity limits.





From the M5 proposal: galaxy evolution chapter

Conclusions

Compton thick hunting season re-opened

Heavily Compton thick AGN could be responsible of the "mass excess", satisfy the constraints imposed by the XRB and FIRB and accrete "efficiently". Need to be either X-ray silent and/or highly covered. They could be associated with the rapid obscured growth of SMBH envisaged by theoretical models.

Likely to be luminous infrared sources with AGN signatures in the IR spectrum

Deep Chandra/XMM and NuSTAR coupled with multi-wavelength observations may provide interesting constraints

ATHENA & SPICA will allow to explore the entire parameter space