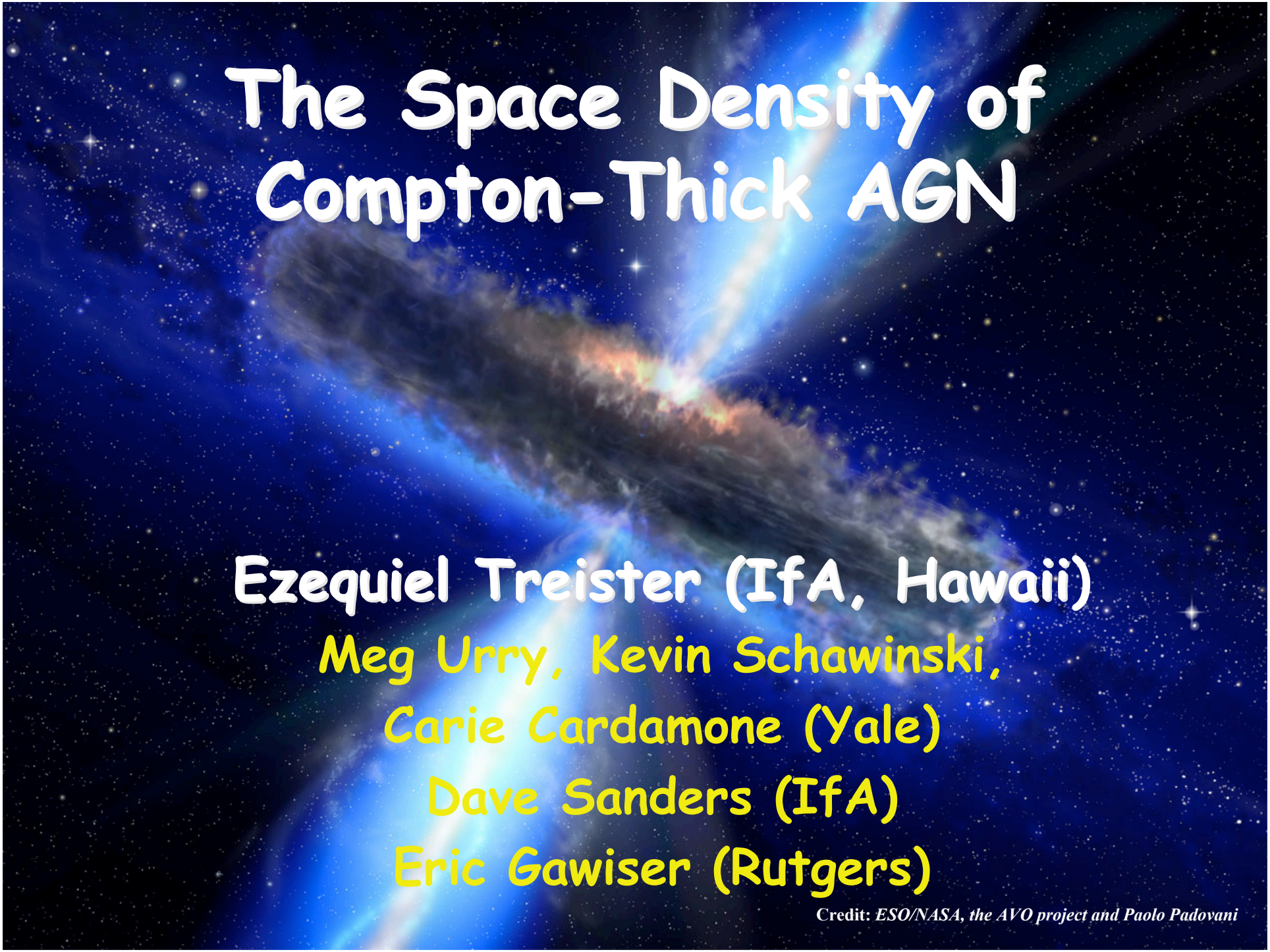
The Space Density of Compton-Thick AGN

Ezequiel Treister (IfA, Hawaii)
Meg Urry, Kevin Schawinski,
Carie Cardamone (Yale)
Dave Sanders (IfA)
Eric Gawiser (Rutgers)

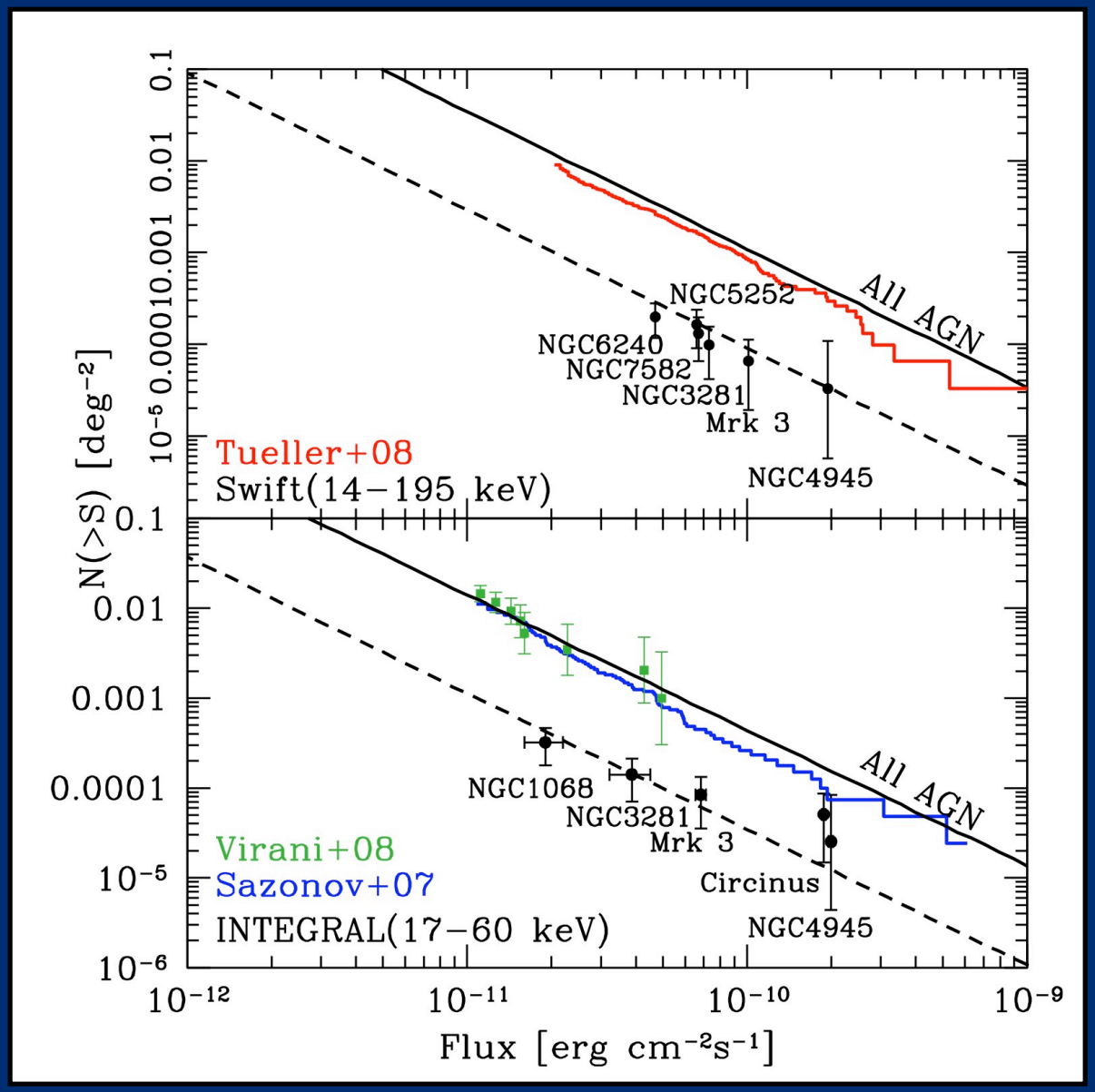


Credit: *ESO/NASA, the AVO project and Paolo Padovani*

Compton Thick AGN

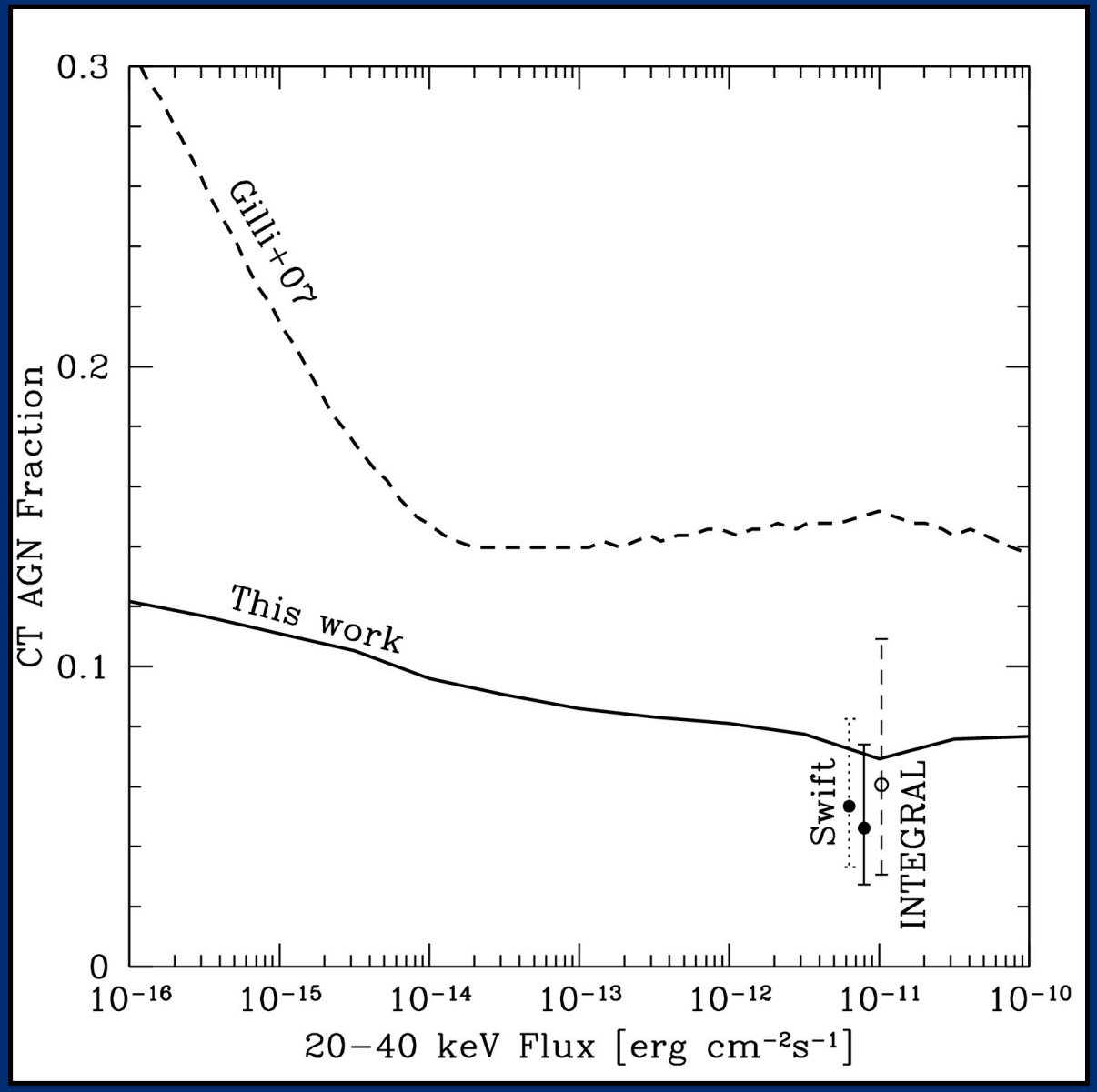
- Defined as obscured sources with $N_H > 10^{24}$ cm^{-2}.
- Very hard to find (even in X-rays).
- Observed locally and needed to explain the X-ray background.
- Number density highly uncertain.
- May contribute significantly to SMBH accretion.
- Multiwavelength observations are required to find them.
- Hard X-rays (E>10keV) surveys with INTEGRAL and Swift very useful locally.

Log N-Log S



Treister et al. 2009

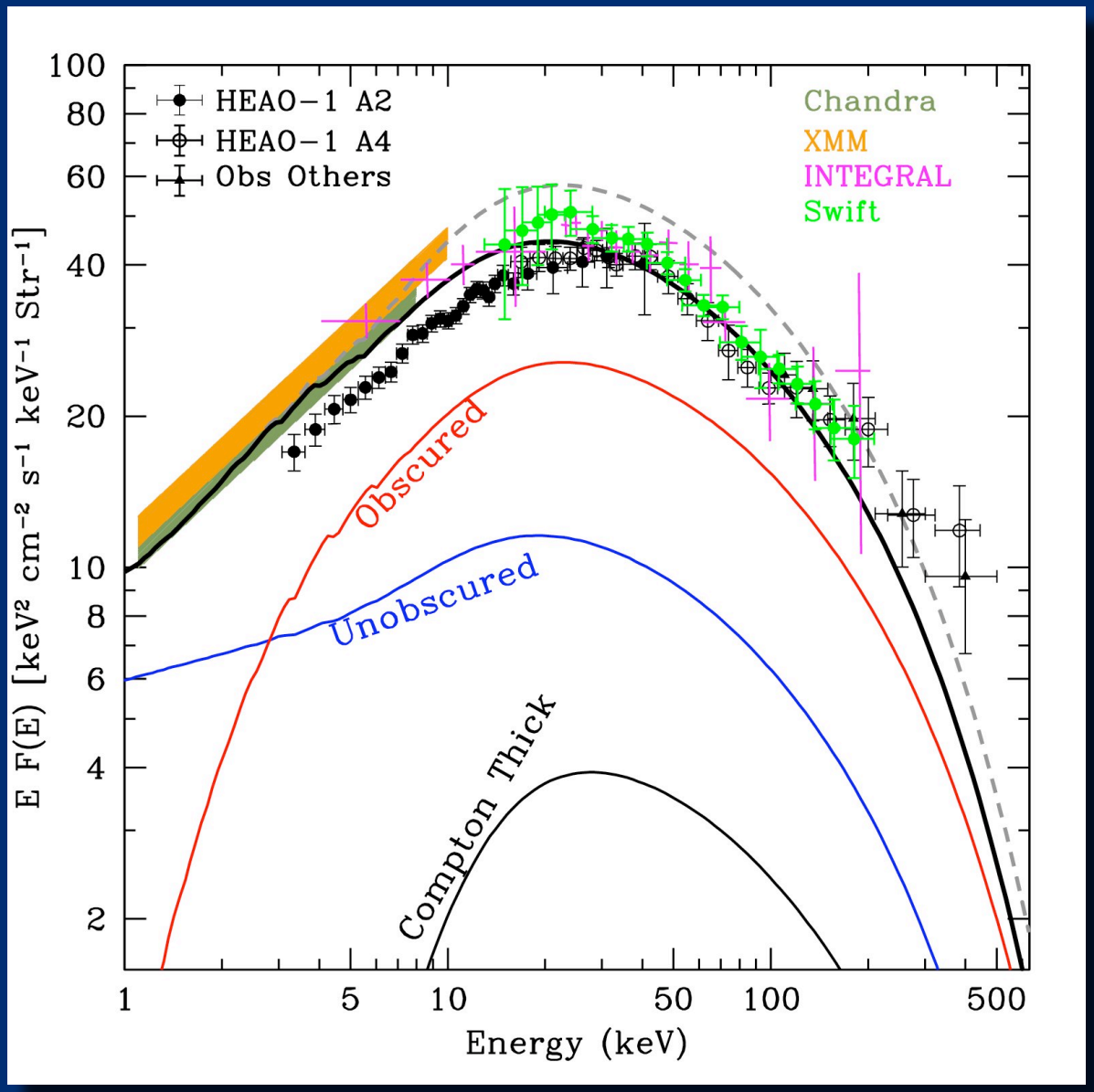
Fraction of CT AGN



X-ray background does not constrain density of CT AGN

Treister et al. 2009

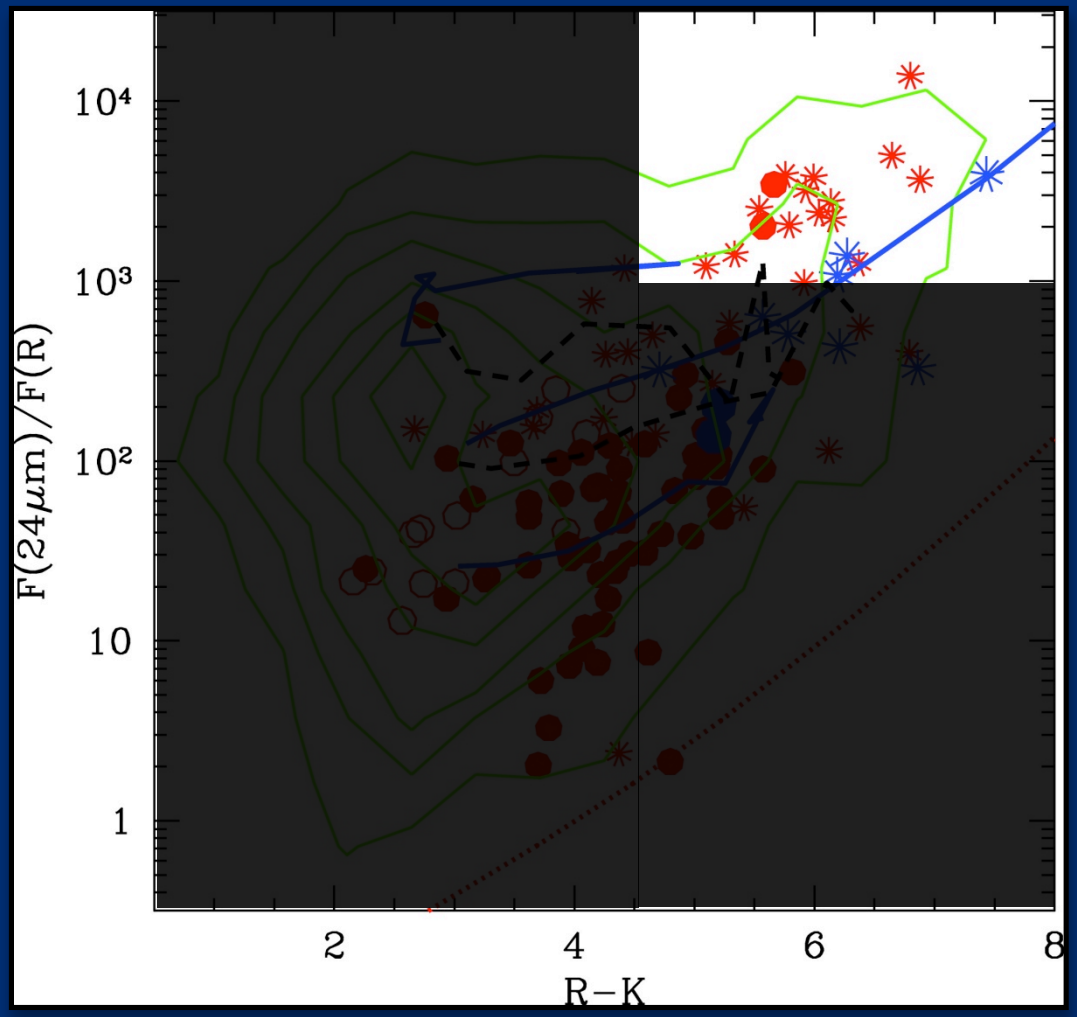
X-Ray Background Synthesis



Treister et al. 2009

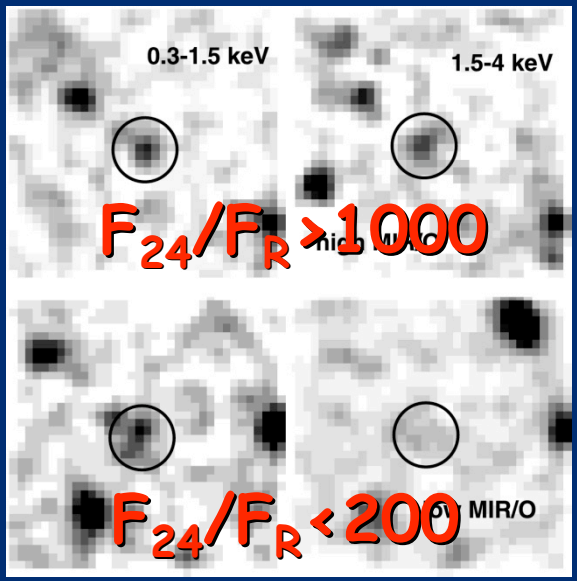
How to find high-z CT AGN?

Mid-IR Selection



Fiore et al. 2008

X-ray Stacking



- 4σ detection in X-ray stack. Hard spectral shape, harder than X-ray detected sources. →Good CT AGN candidates.
- Similar results found by Daddi et al. (2007)

Extended Chandra Deep Field-South

Area: 0.3 deg^2

X-rays: Chandra 250ks/pointing

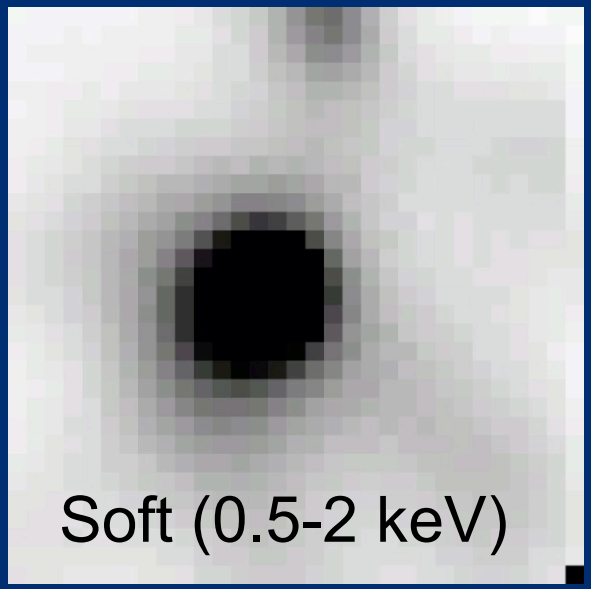
Optical: Broad band UBVRIz (V=26.5)+ 18 Medium band filters (to R=26)

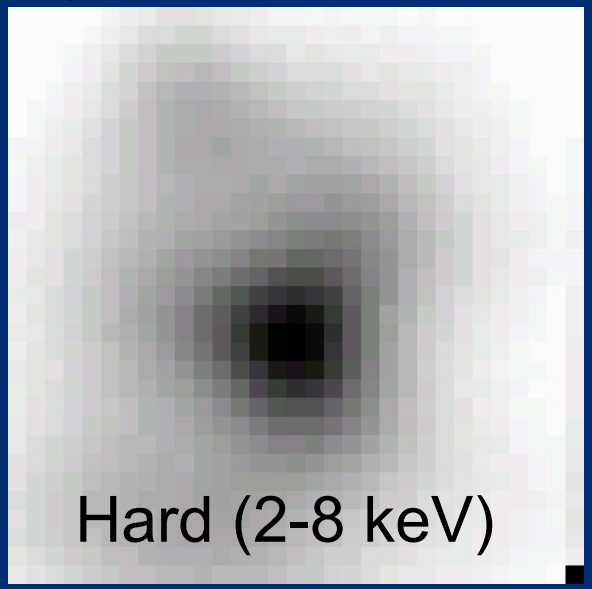
Near-IR: JHK to K=20 (Vega)

Mid-IR: IRAC 3.6-8 microns + MIPS 24 microns to 35 μJy

Spectroscopy: VLT/VIMOS, Magellan/IMACS (optical) VLT/SINFONI, Subaru/MOIRCS (near-IR)

Stacking of non-Xrays Sources

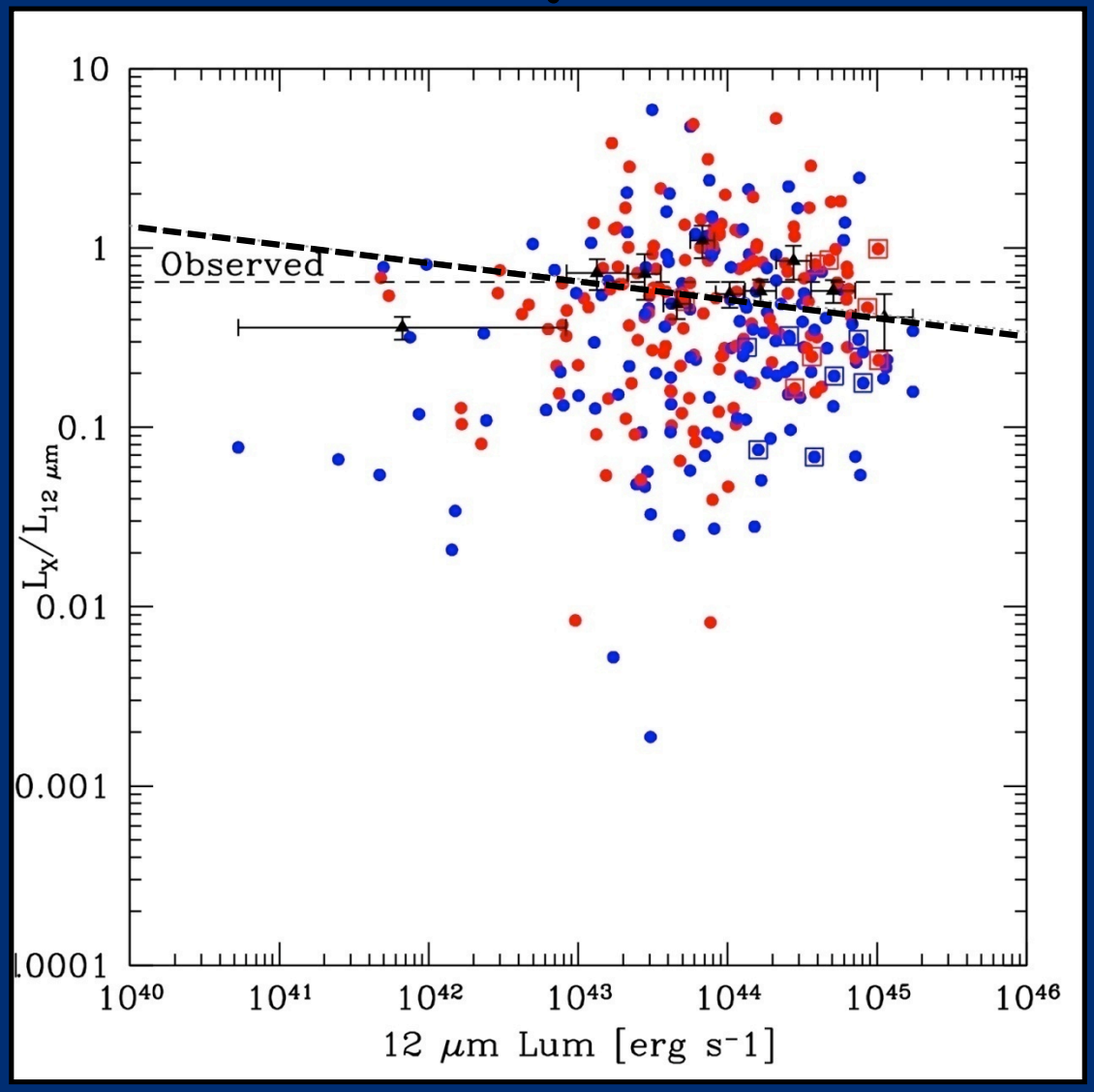




- 211 Spitzer-selected sources
- ~4σ detection in each band.
- f_{soft}=2.1x10^{-17}erg cm^{-2}s^{-1}. F_{hard}= 8x10^{-17}erg cm^{-2}s^{-1}
- Sources can be detected individually in ~10 Msec.
- Hardness ratio 0.13, N_H=1.8x10^{23}cm^{-2}.
- Alternatively, ~90% CT AGN and 10% star-forming galaxies.
- Some evidence for a flux dependence. >95% CT AGN at the brightest bin, 80% at the lowest. Large error bars.

Treister et al. ApJ submitted

X-Ray to Mid-IR Ratio

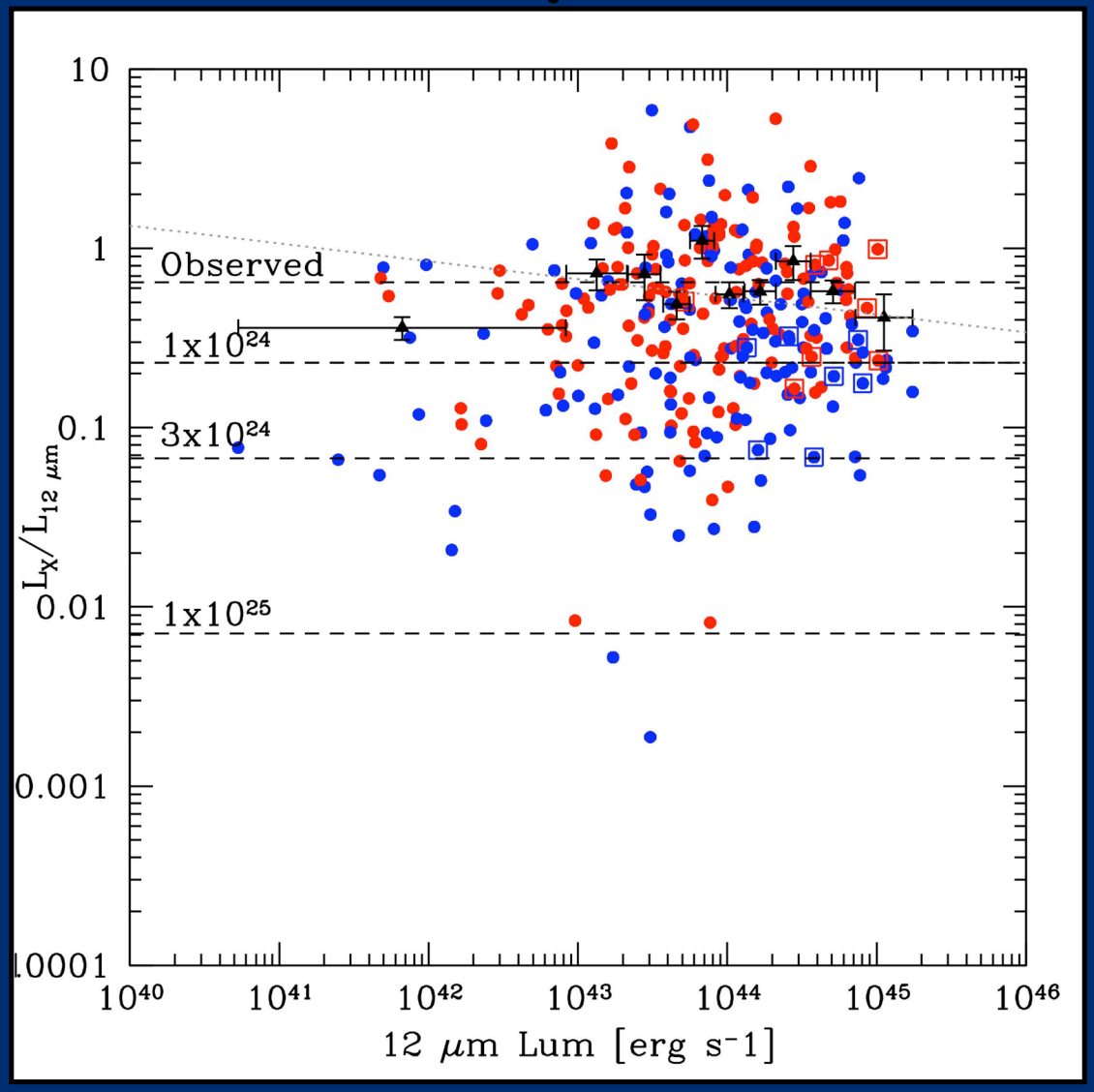


Both X-rays and 12μm good tracers of AGN activity.

Observed ratios for X-ray sources consistent with local AGN (poster by P. Ghandi).

Treister et al. ApJ submitted

X-Ray to Mid-IR Ratio

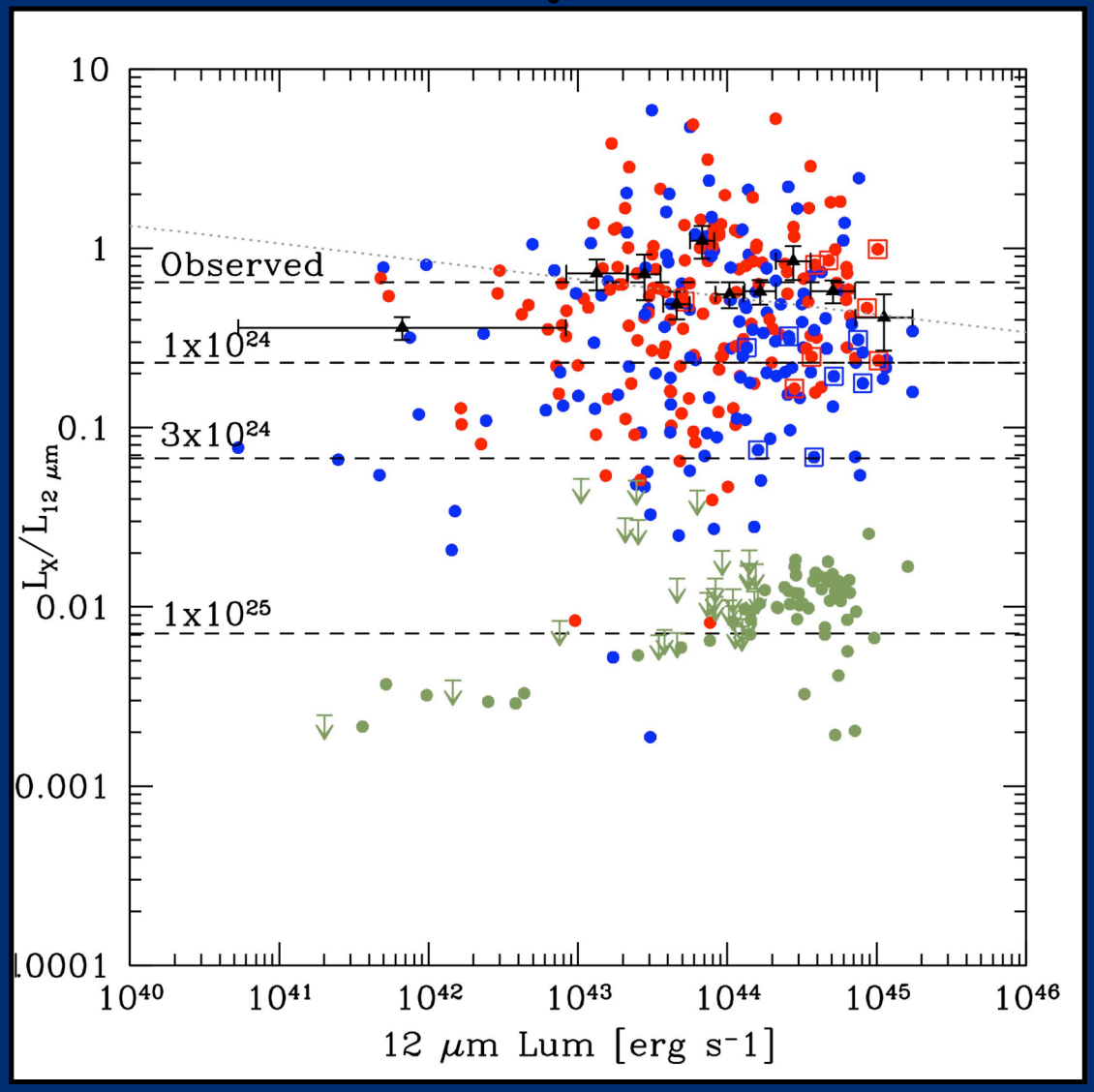


Effects of obscuration in X-ray band luminosity.

Only important for Compton Thick sources.

Treister et al. ApJ submitted

X-Ray to Mid-IR Ratio

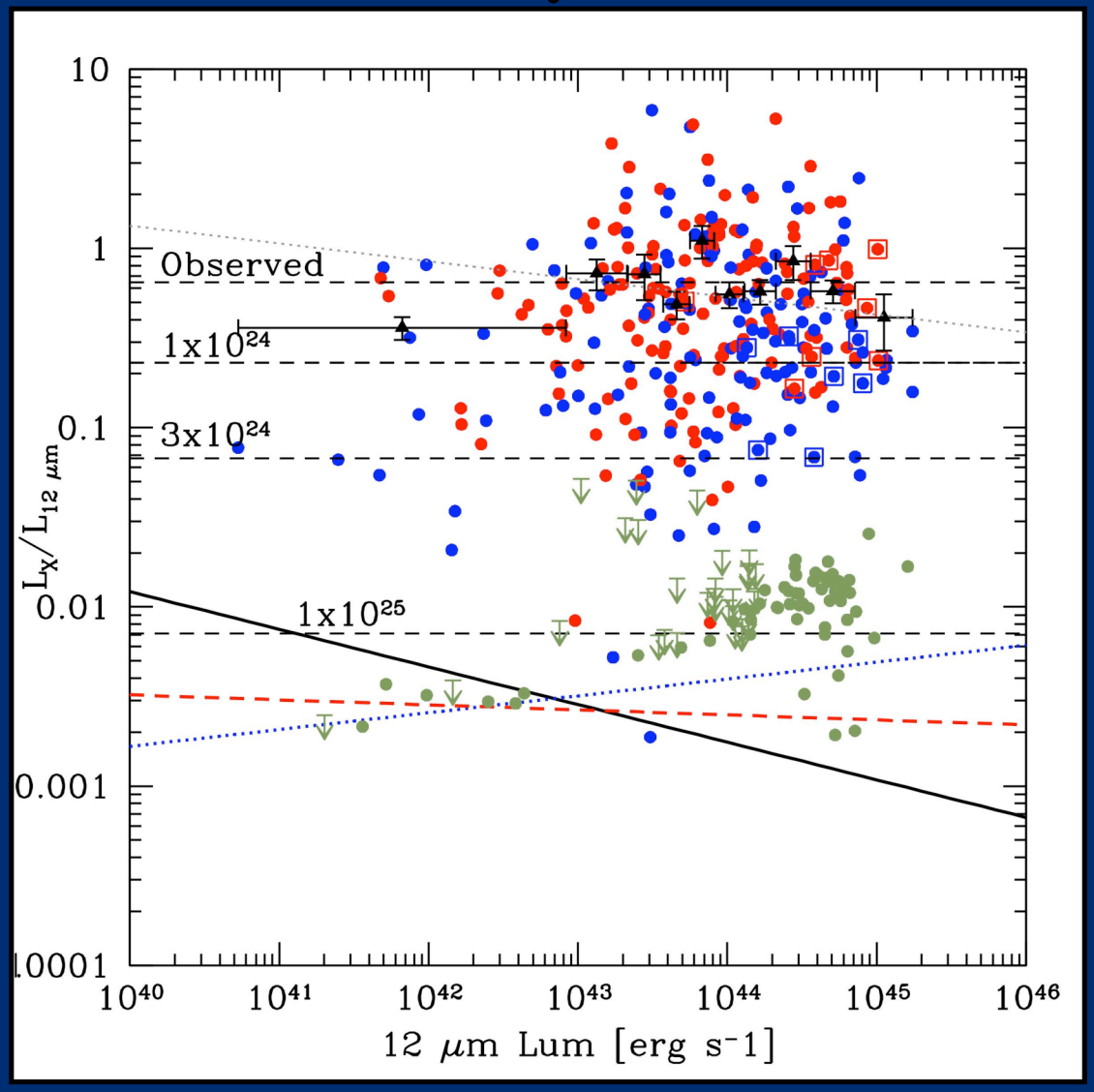


~100x lower ratio for X-ray undetected sources.

Explained by N_H~5×10^{24} to 10^{25} cm^{-2}

Treister et al. ApJ submitted

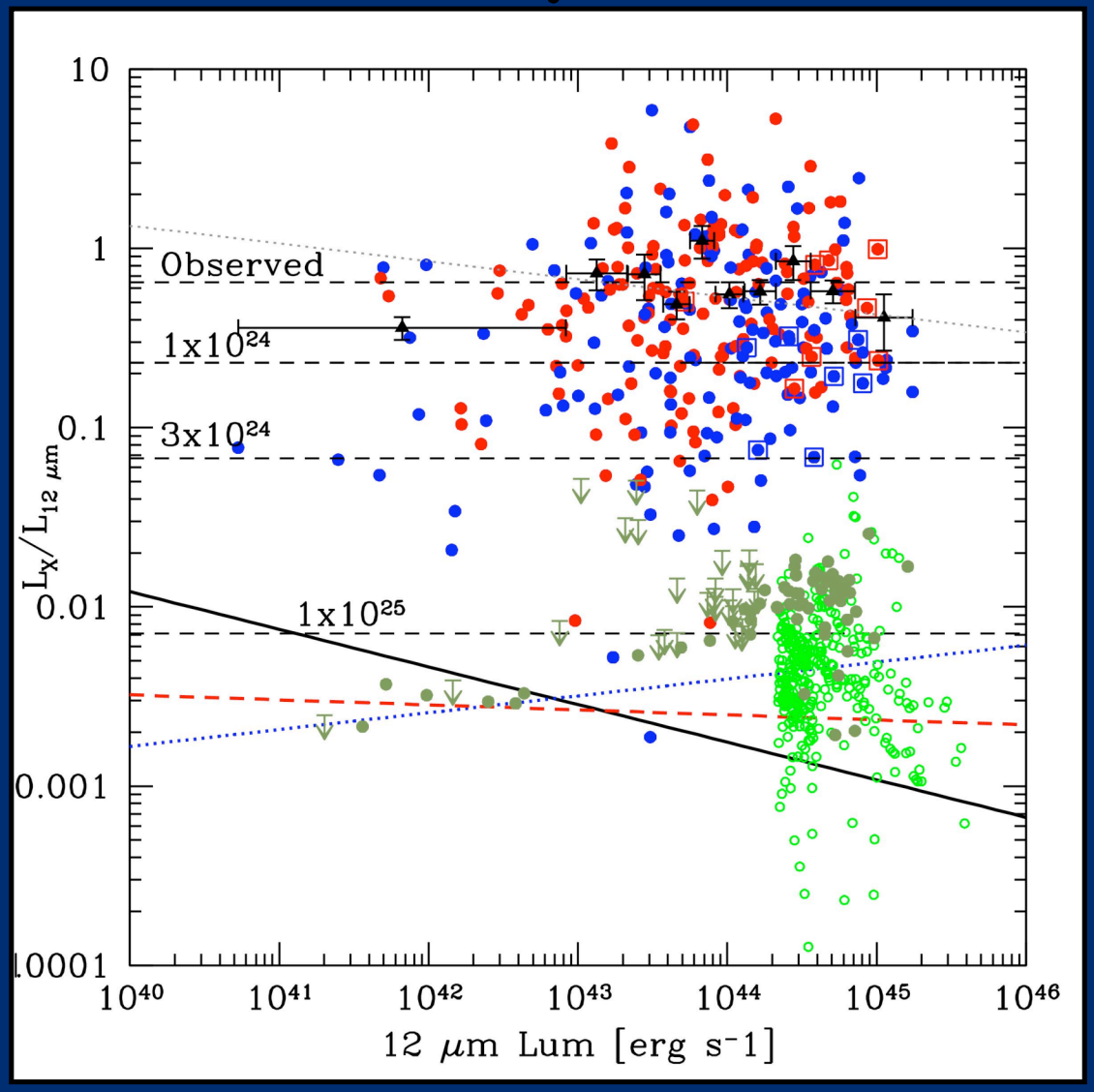
X-Ray to Mid-IR Ratio



Ratio for sources with $L_{12\mu m}$>10^{43}erg/s (~80% of the sources) ~2-3x higher than star-forming galaxies

Treister et al. ApJ submitted

X-Ray to Mid-IR Ratio

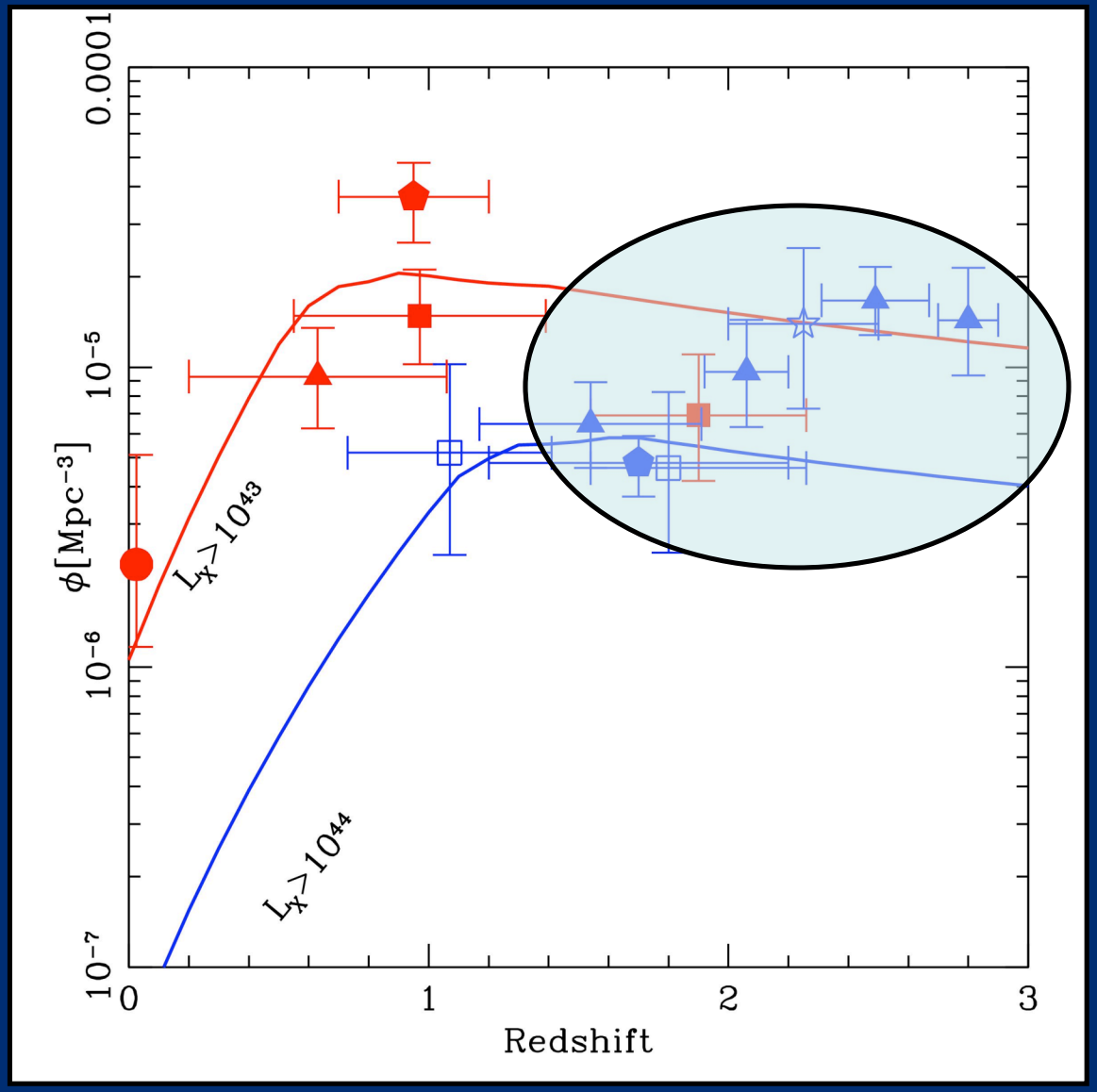


Using $Lx/L_{12\mu m}$=0.007 to separate AGN and star-forming galaxies → ~80% AGN, consistent with HR value.

In sources with $L_{12\mu m}>10^{44}$erg/s outside selection region fraction of AGN ~10%.

Treister et al. ApJ submitted

CT AGN Space Density



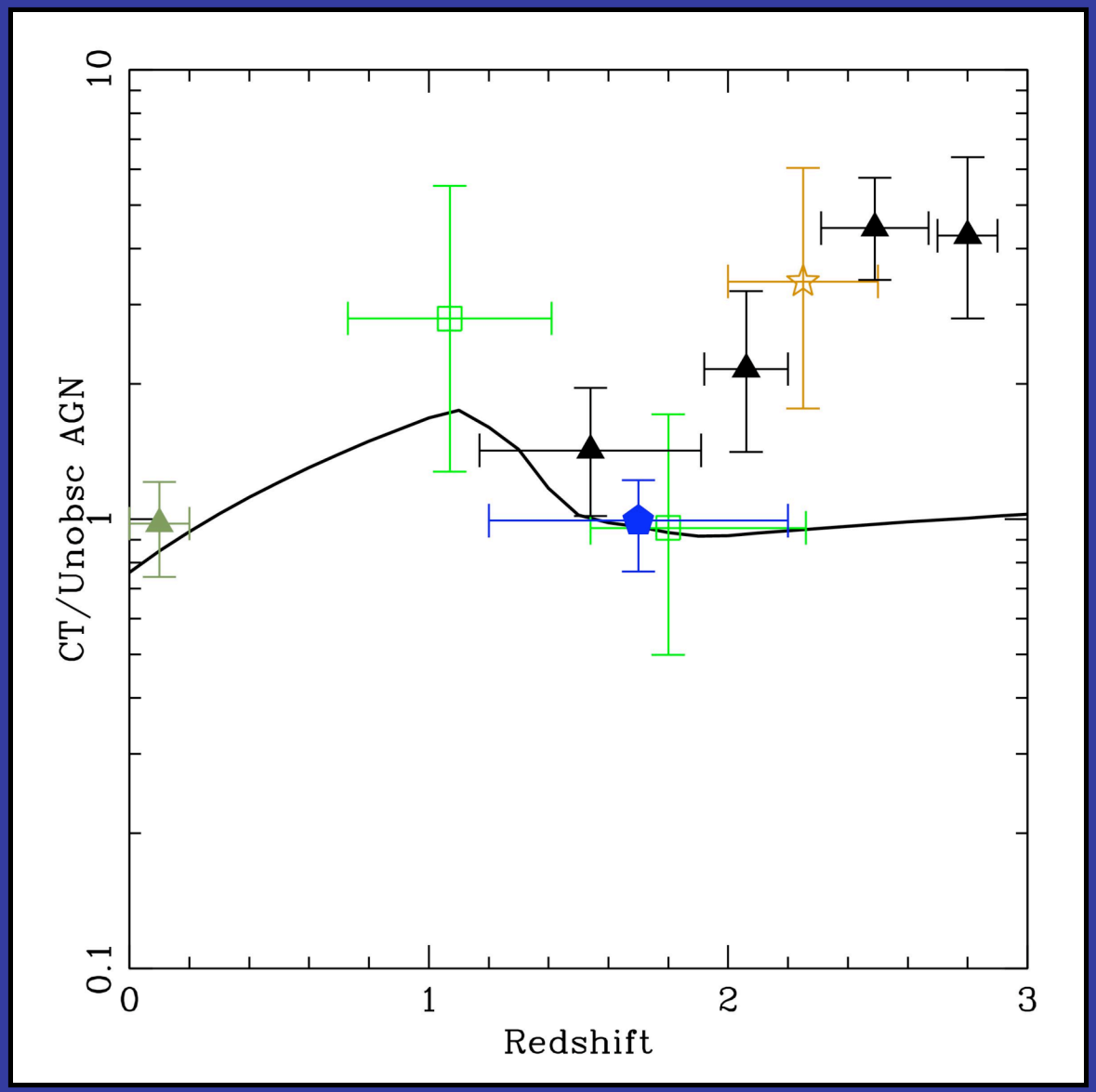
Systematic excess for L_x>10^{44}erg/s sources relative to extrapolation of Compton-thin LF

Strong evolution in number of sources from z=1.5 to 2.5.

Consistent with heavily-obscured phase after merger?

Treister et al. ApJ submitted

CT to Unobscured Quasar Ratio

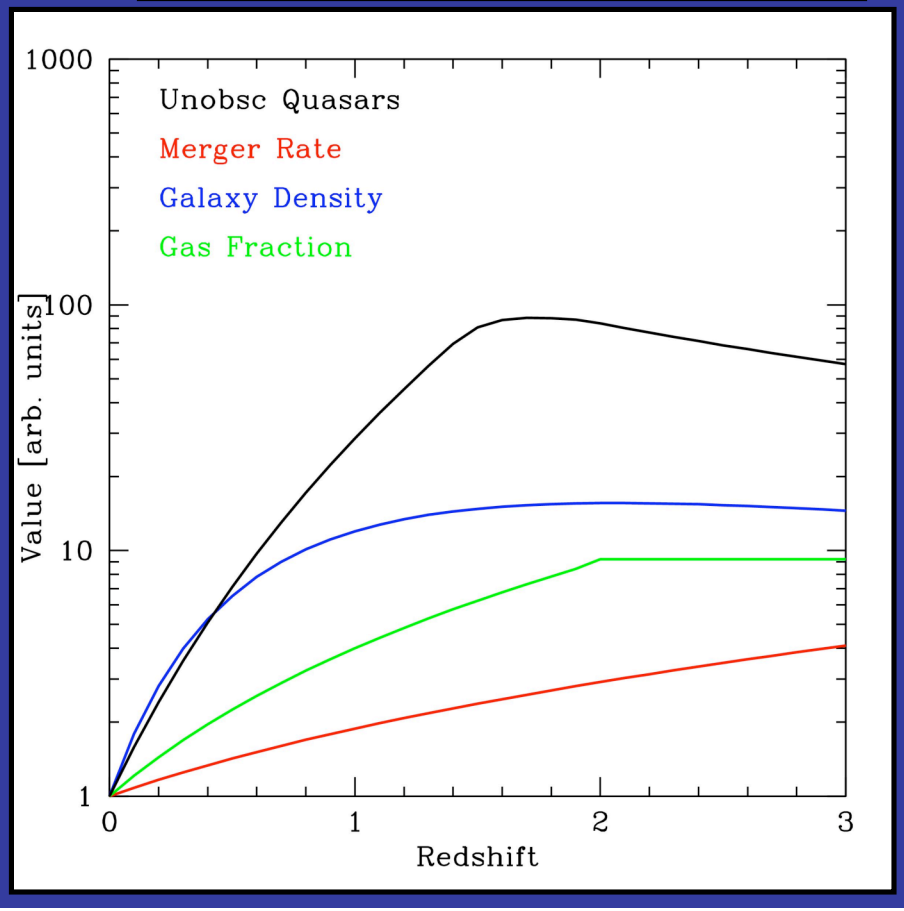


Treister et al. in prep.

The Merger-Quasar Connection

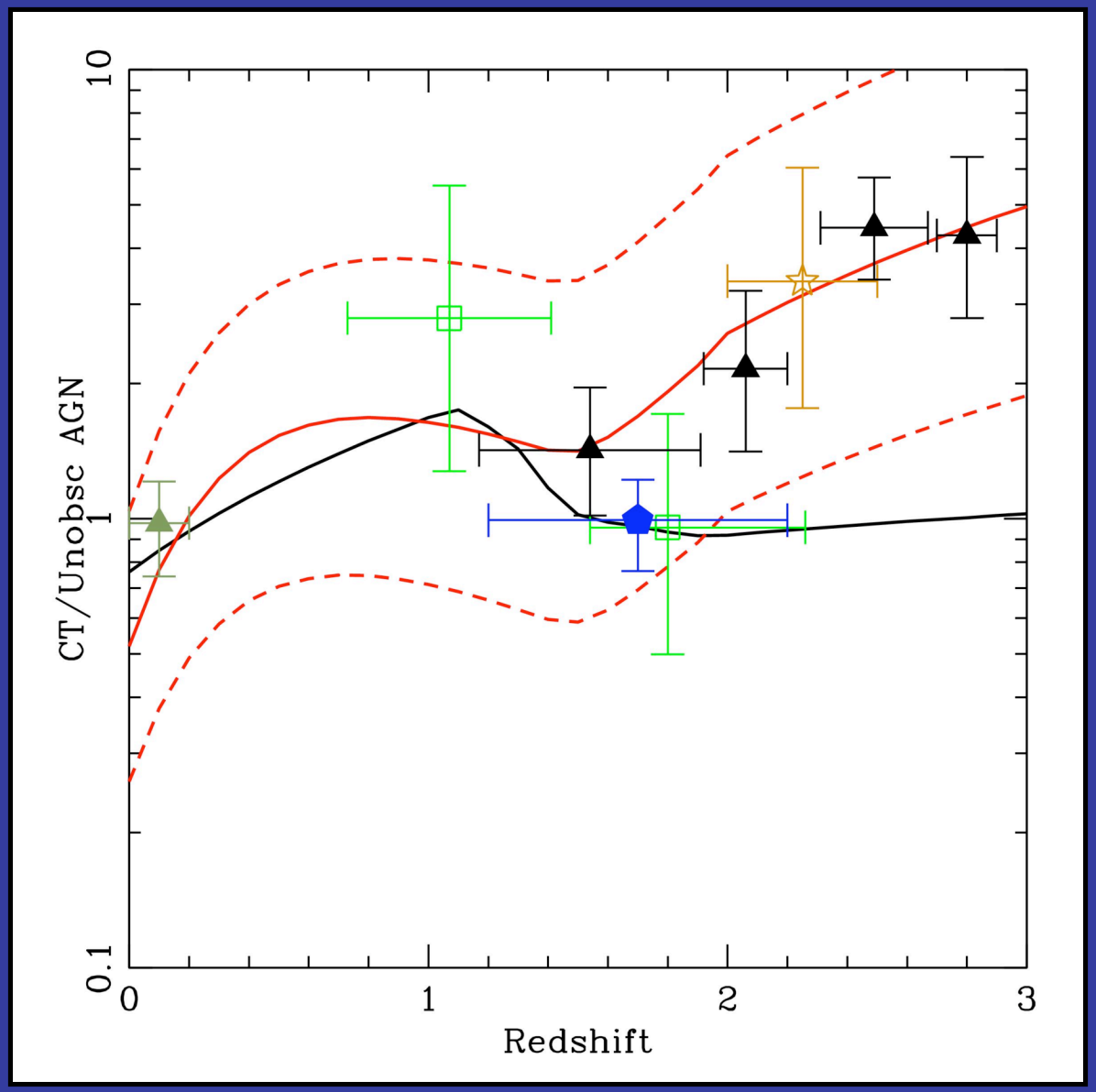
Obscured quasars are the product of the merger of two massive gas-rich galaxies. After a time Δt the quasar becomes unobscured.

$$\frac{N_{obsc}}{N_{Unobsc}}(z) = \frac{\Delta t \frac{dmerger}{dtdN} N_{gal}(> M_{\min}(z)) f_{gas}(z)}{N_{Unobsc}(z)}$$



Treister et al. in prep.

The Merger-Quasar Connection



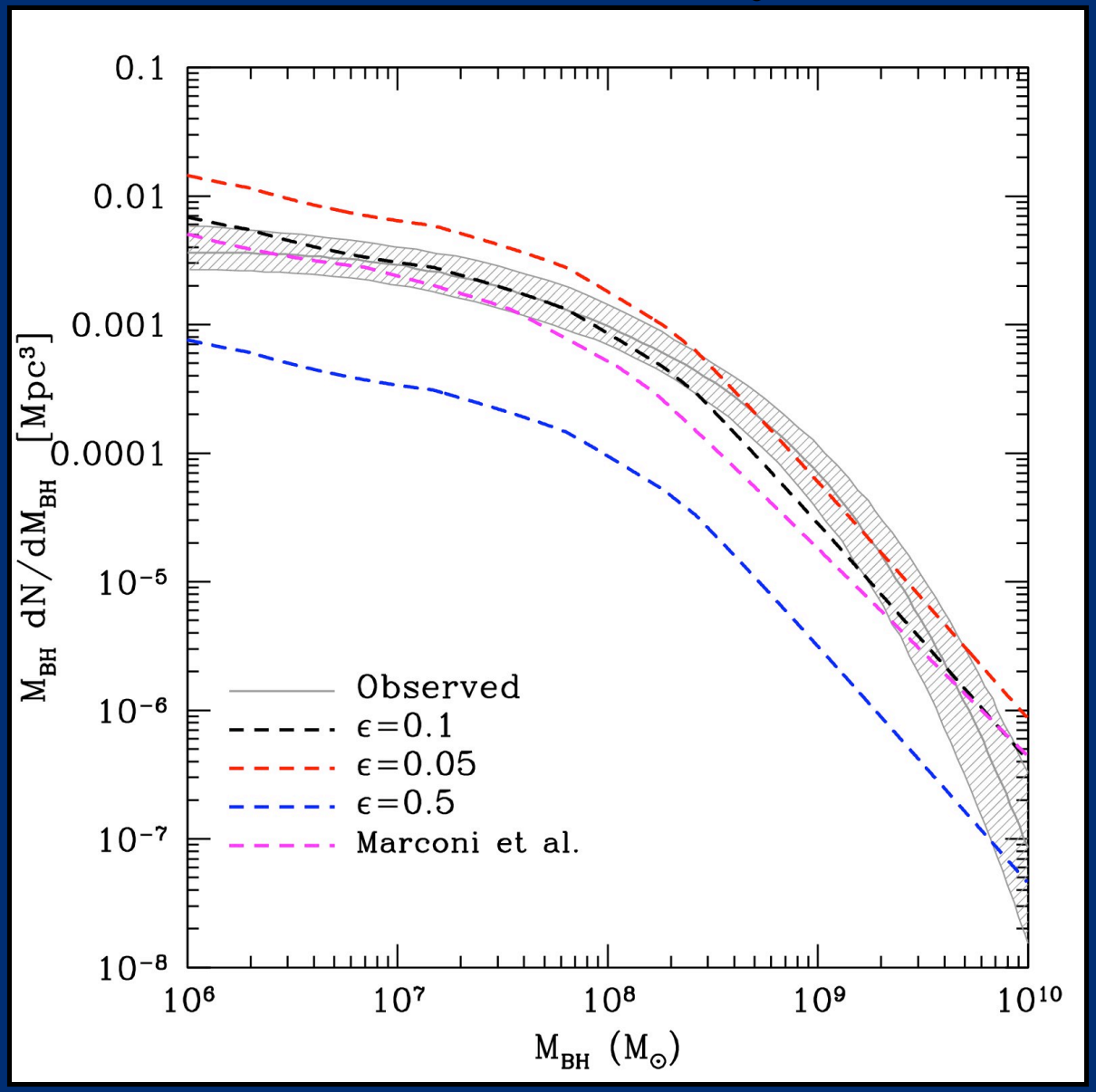
$\Delta t \approx 100$ Myrs

Extra sources do not contribute much to XRB

However, they can contribute to integrated SMBH density.

Treister et al. in prep.

SMBHs Spatial Density



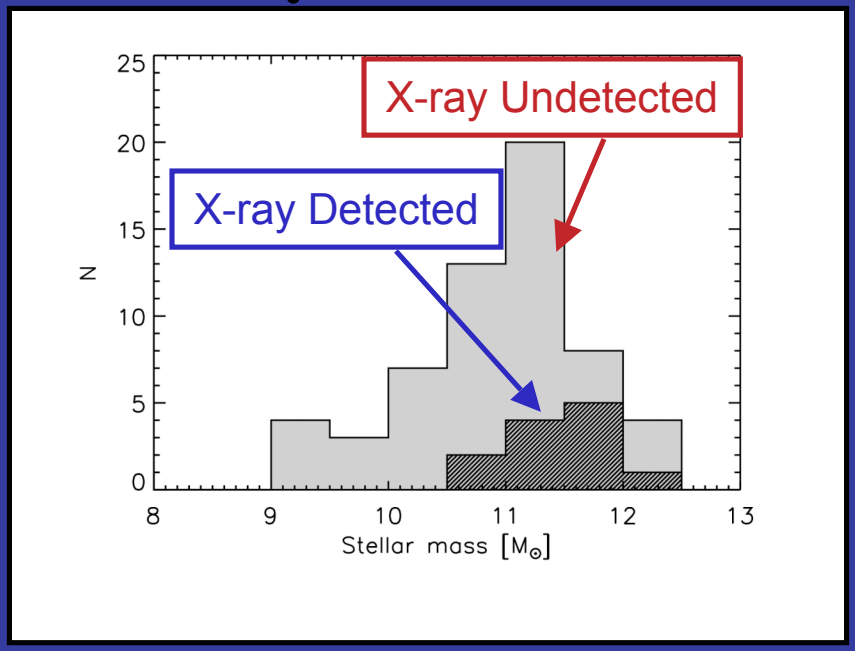
Most of the BH mass accreted in one of these luminous phases.

Accretion efficiency ≤10%

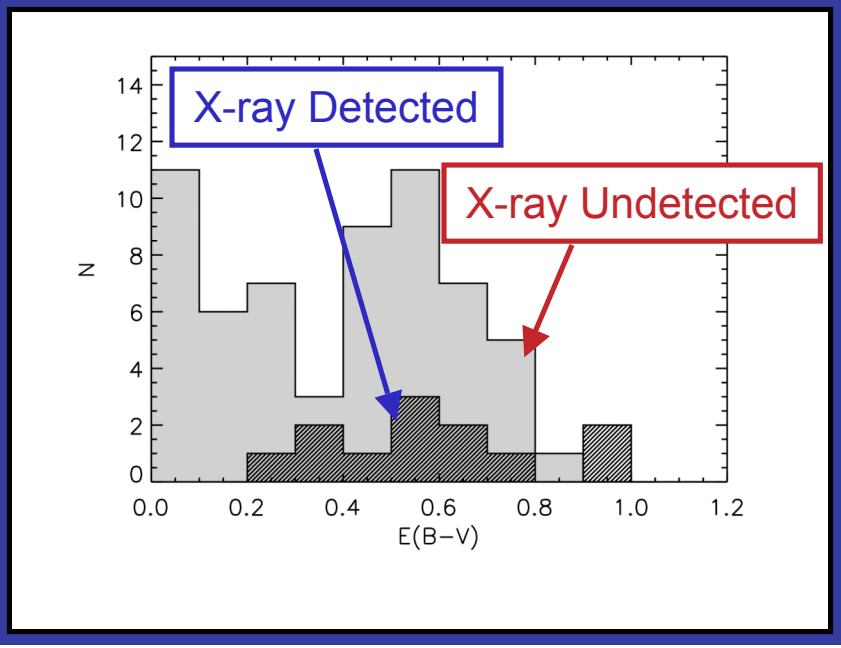
Summary

- Number of mildly CT sources at z~0 lower than expected.
- Mid-IR selection finds large number of CT AGN at z>1.5. Strong evolution in numbers up to z~3.
- This can be explained if new quasars caused by major merger of two massive gas-rich galaxies.
- Time scale for obscured AGN phase ~100 Myrs.

Optical/Near-IR SED Fitting



- Median stellar mass for X-ray detected sources ~4.6×10^{-11} M_{sun}.
- For X-ray undetected source ~10^{-11} M_{sun}.



- Mild extinction values found in general.
- Maximum Av~4 mags.
- Median E(B-V)=0.6 for X-ray detected sources and 0.4 for undetected ones.

Treister et al. ApJ submitted