Heavily-obscured quasars in star-forming galaxies at z~2

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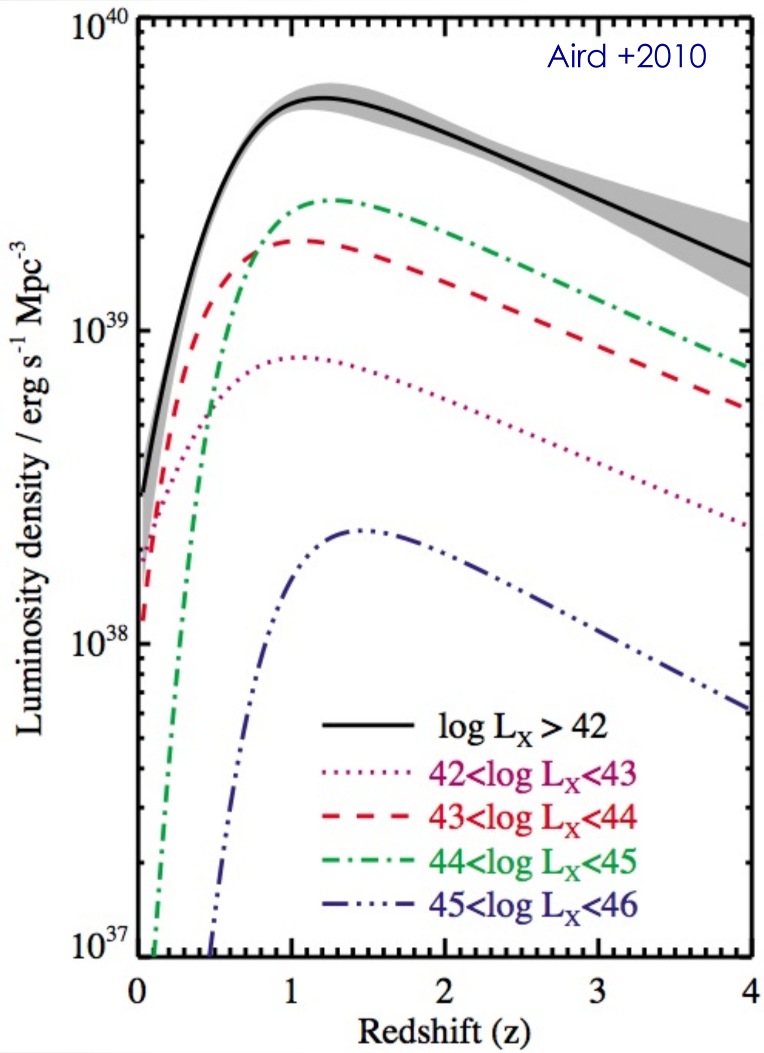
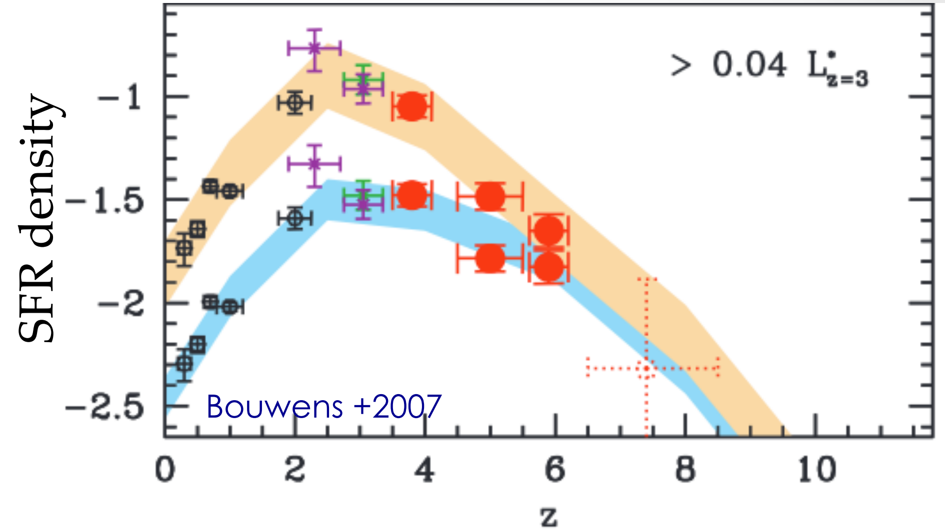
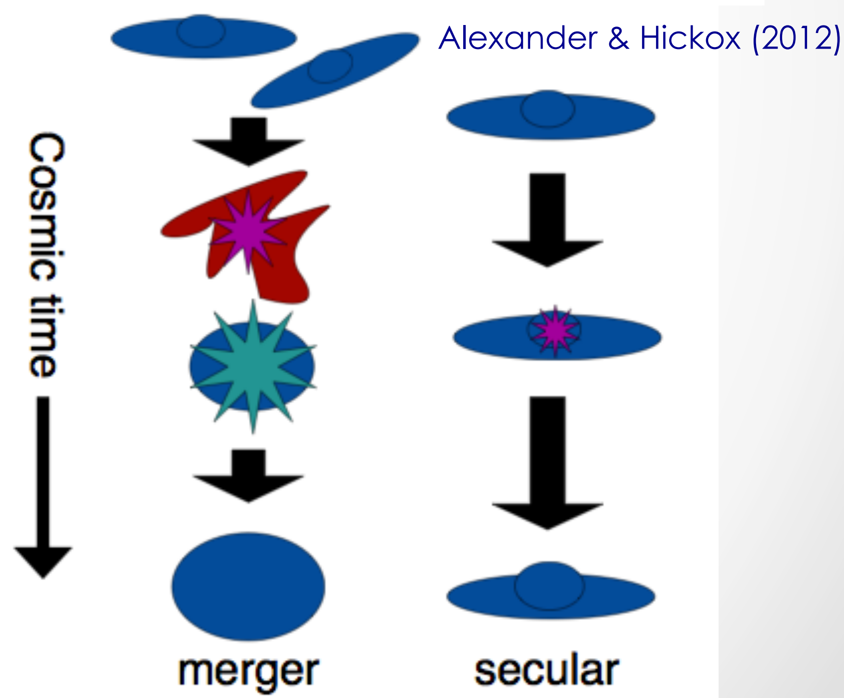
Durham University

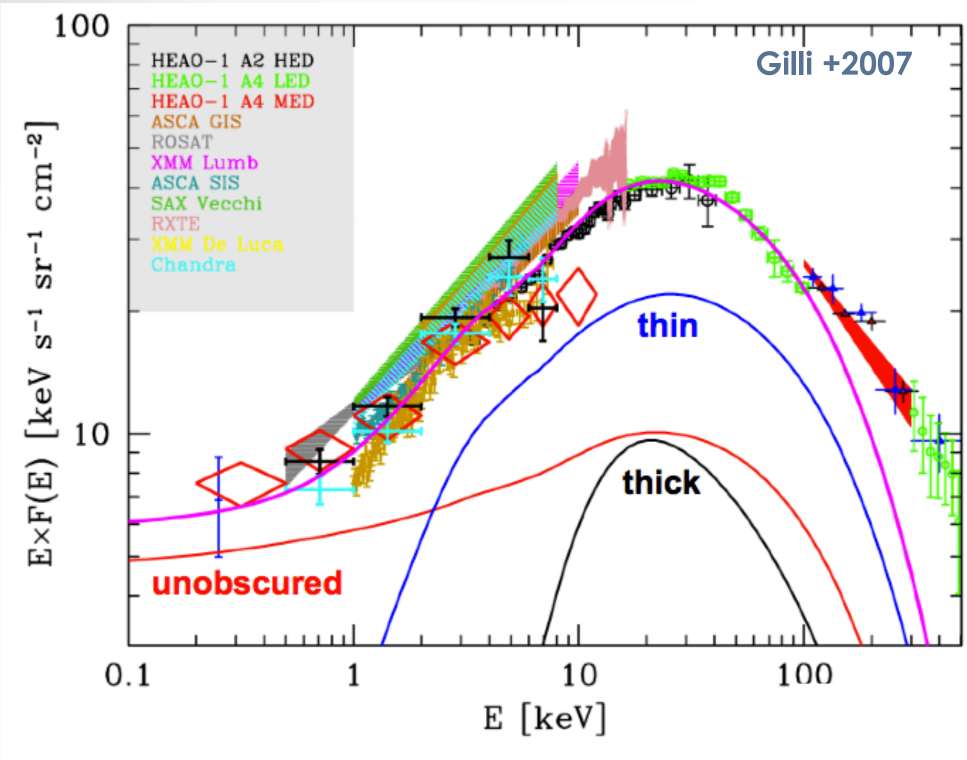
Motivation I: BH-Galaxy coevolution

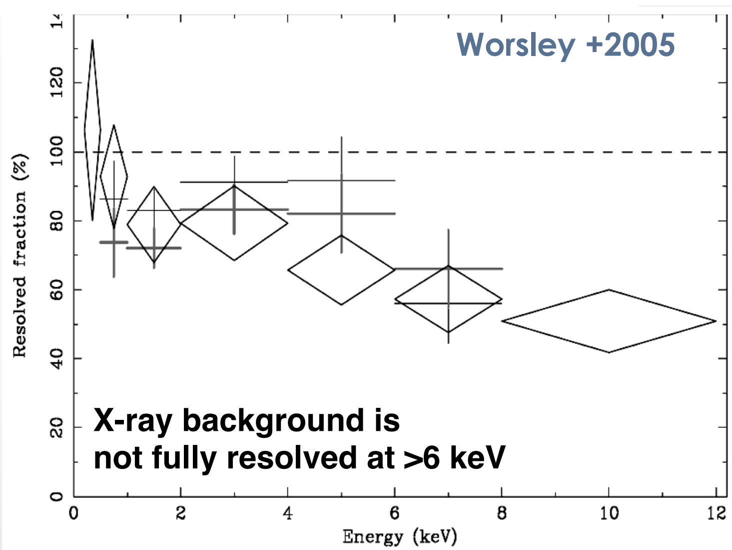






Motivation II: The missing AGN population





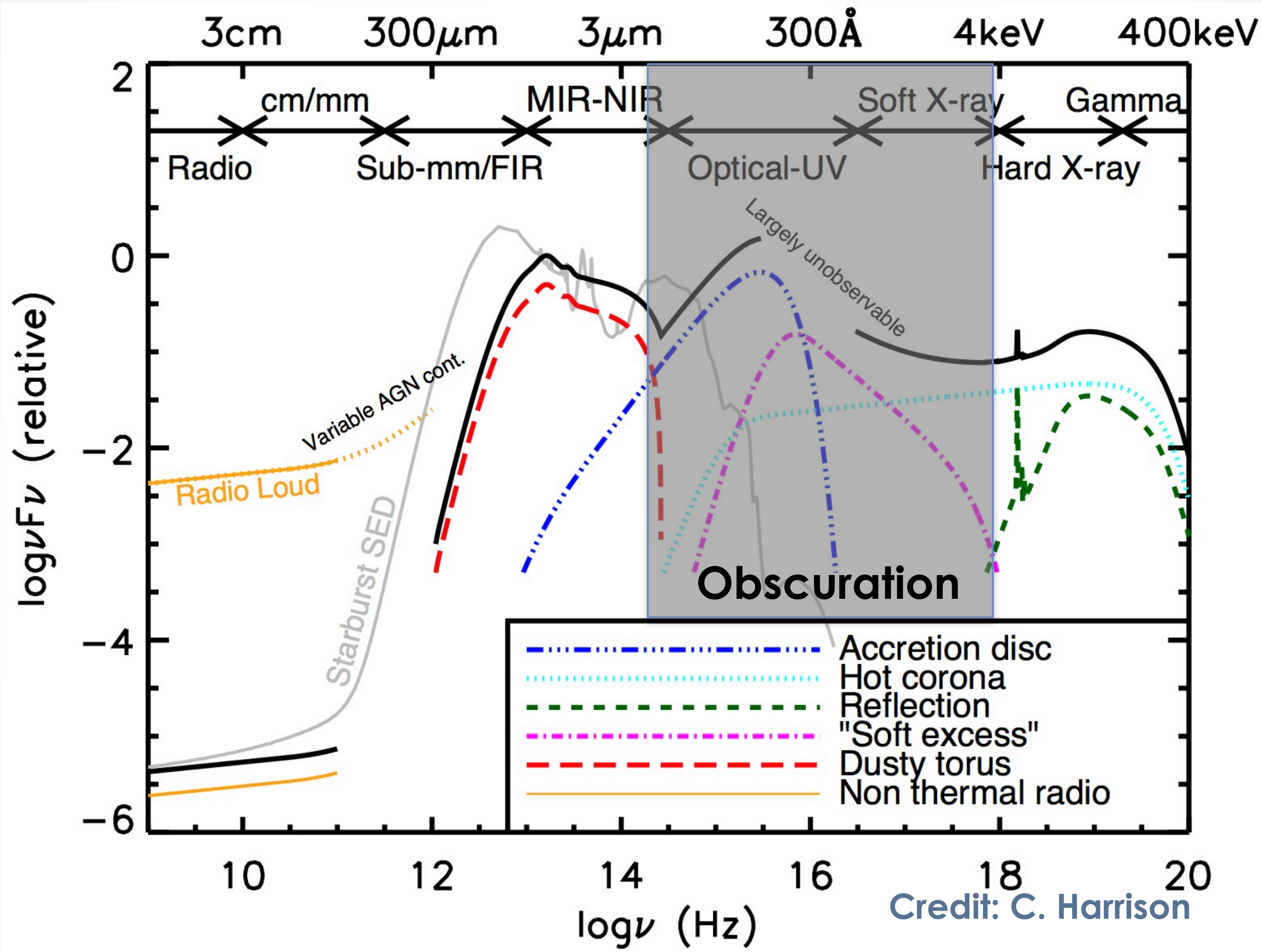
Large fraction of obscured AGN is required to reproduce the XRB peak at ~30 keV

Compton-thick (CT) AGN contribution: ~10-30% (Gilli+2007, Treister+2009)

Deep X-ray surveys have resolved ~70-90% of the X-ray background at E<10 keV (Worsley+2005, Xue+2012)

Only ~1-2% of the XRB directly resolved at ~30 keV (Ajello+2008, Bottacini+2012)

AGN Spectral energy distribution



Credit: C. Harrison

- UV-Optical and Soft X-ray emission are suppressed by obscuration

- IR and Hard X-ray bands are much less affected: more efficient to select obscured AGN

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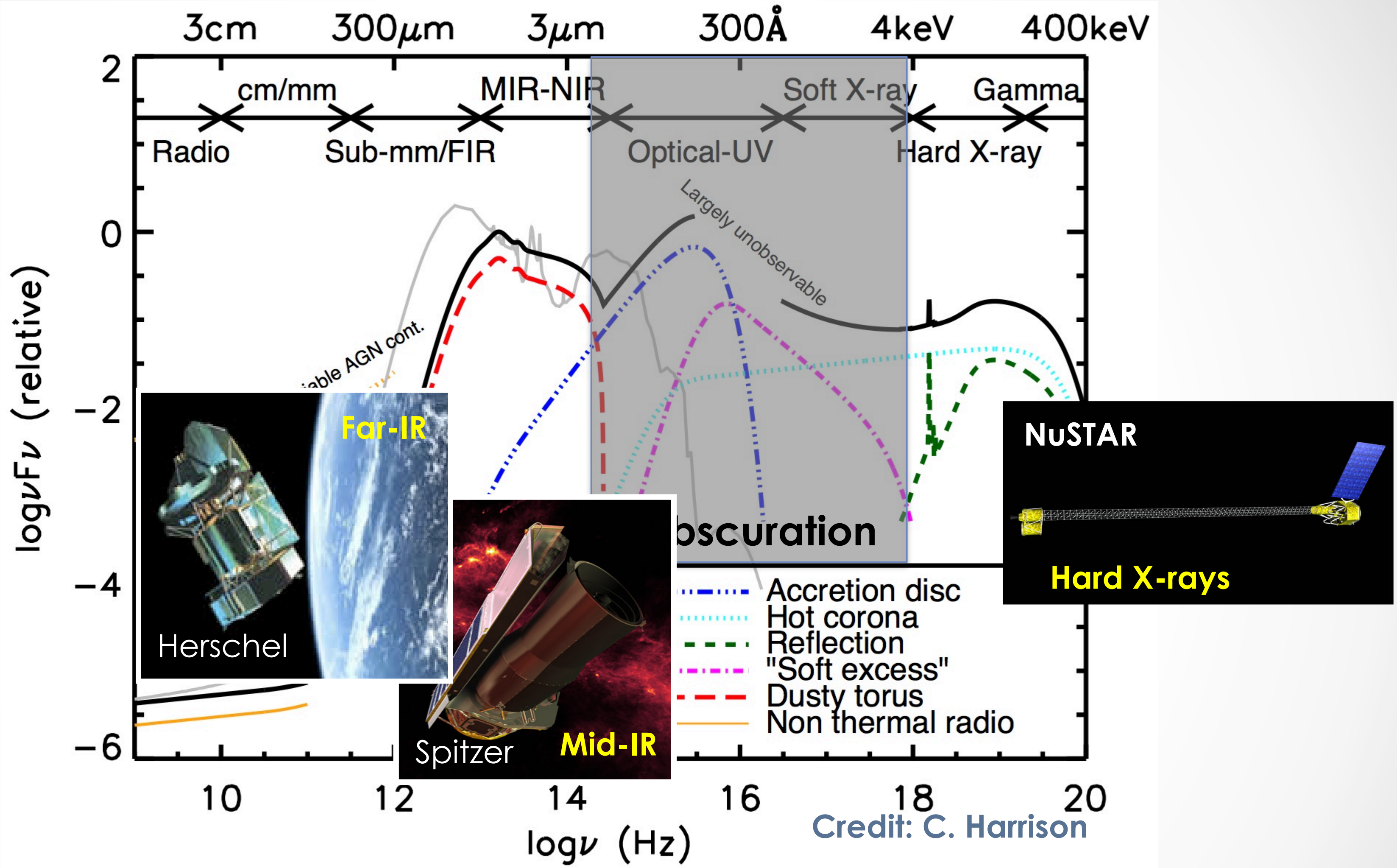

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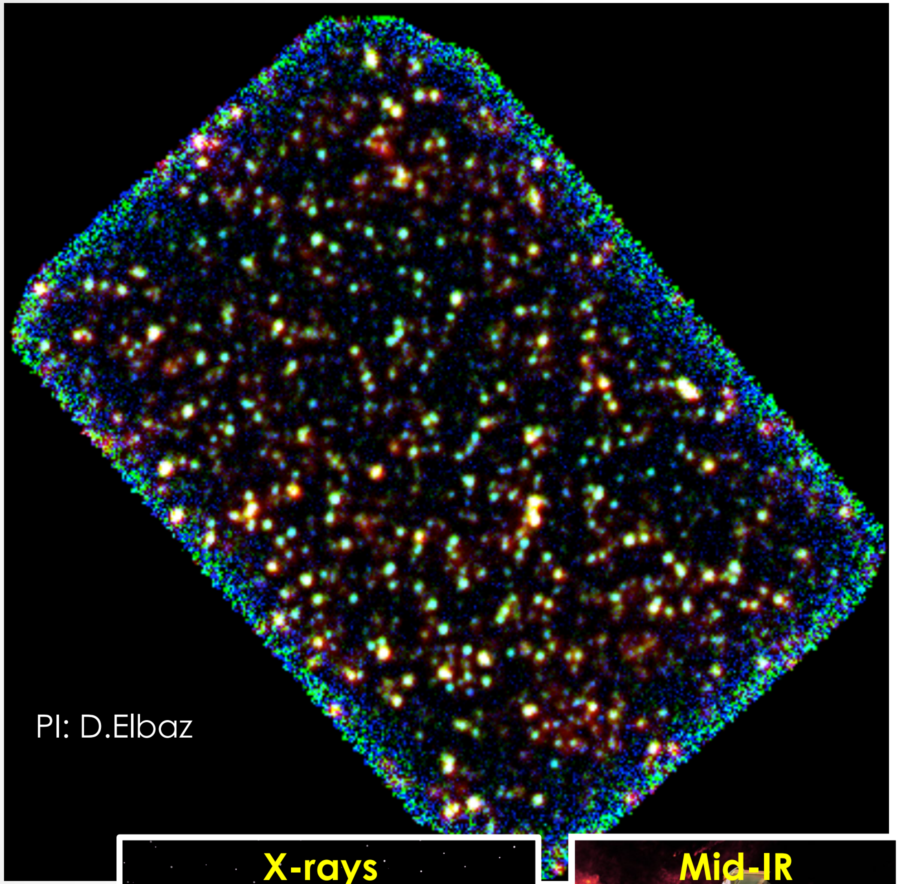
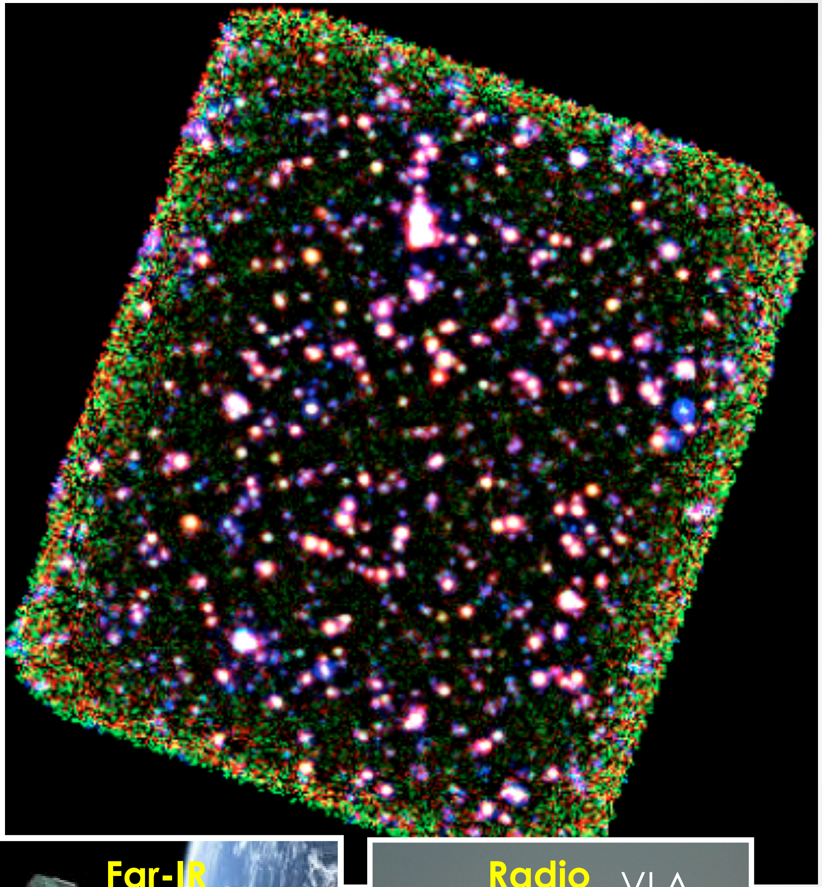
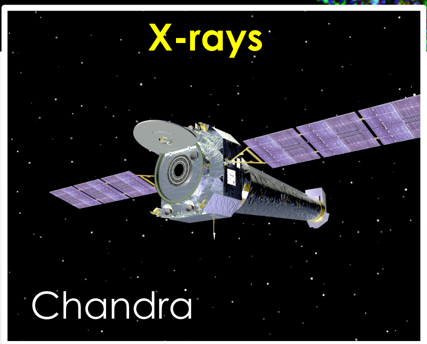
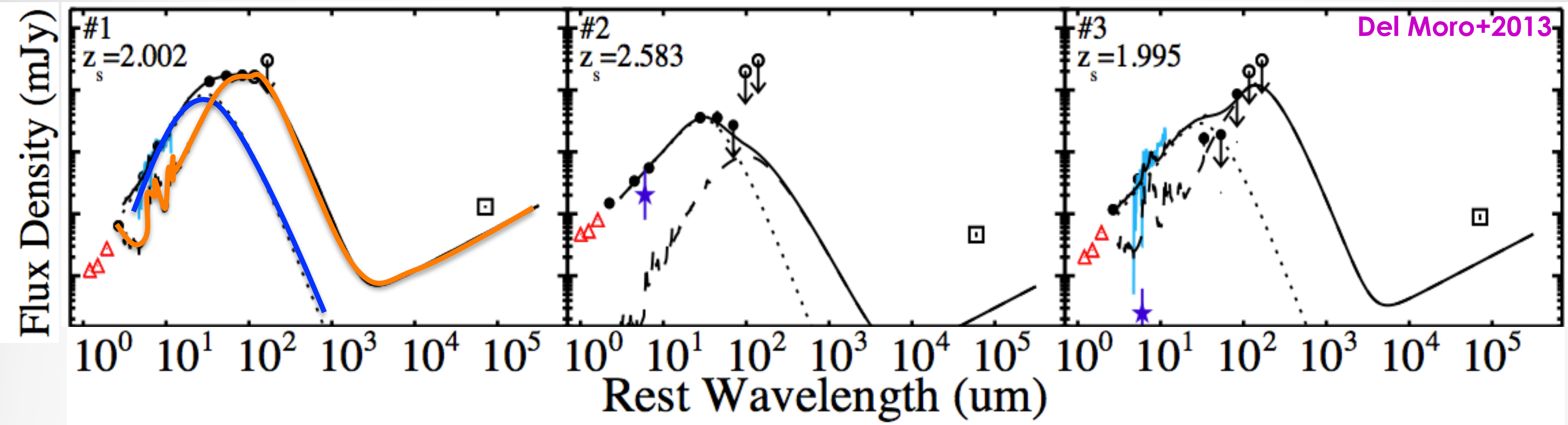
GOODS-Herschel







IR SED Decomposition



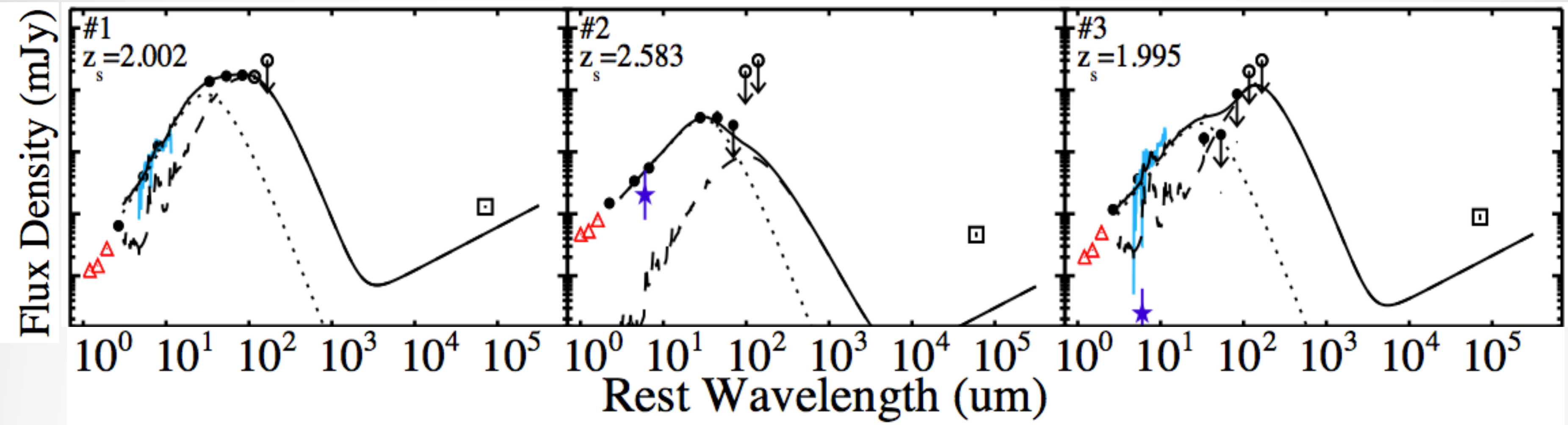
Spitzer: 8, 16, 24 um → Probe of hot dust emission

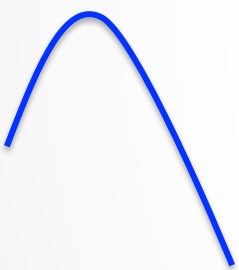
$T_{dust} \approx 200 - 1000$ K

Herschel: 100, 150, 250 um → Probe of cold dust

$T_{dust} \approx 20 - 50$ K

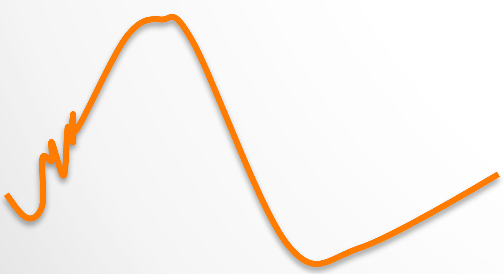
IR SED Decomposition





AGN TEMPLATE (Mullaney+2011)

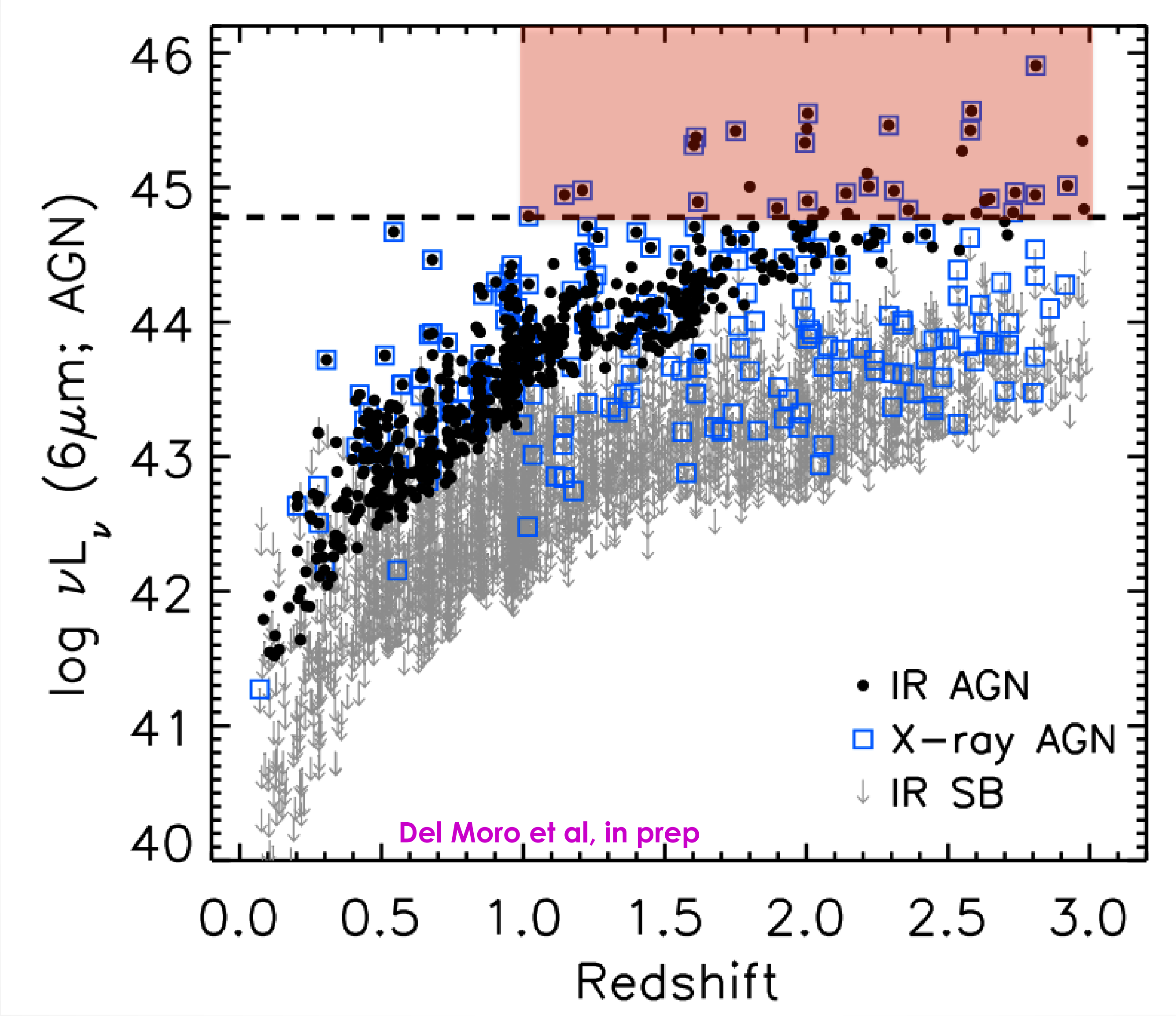
→ **Intrinsic AGN luminosity (L6 um)**



SF GALAXY TEMPLATES (Mullaney+2011, Del Moro +2013)

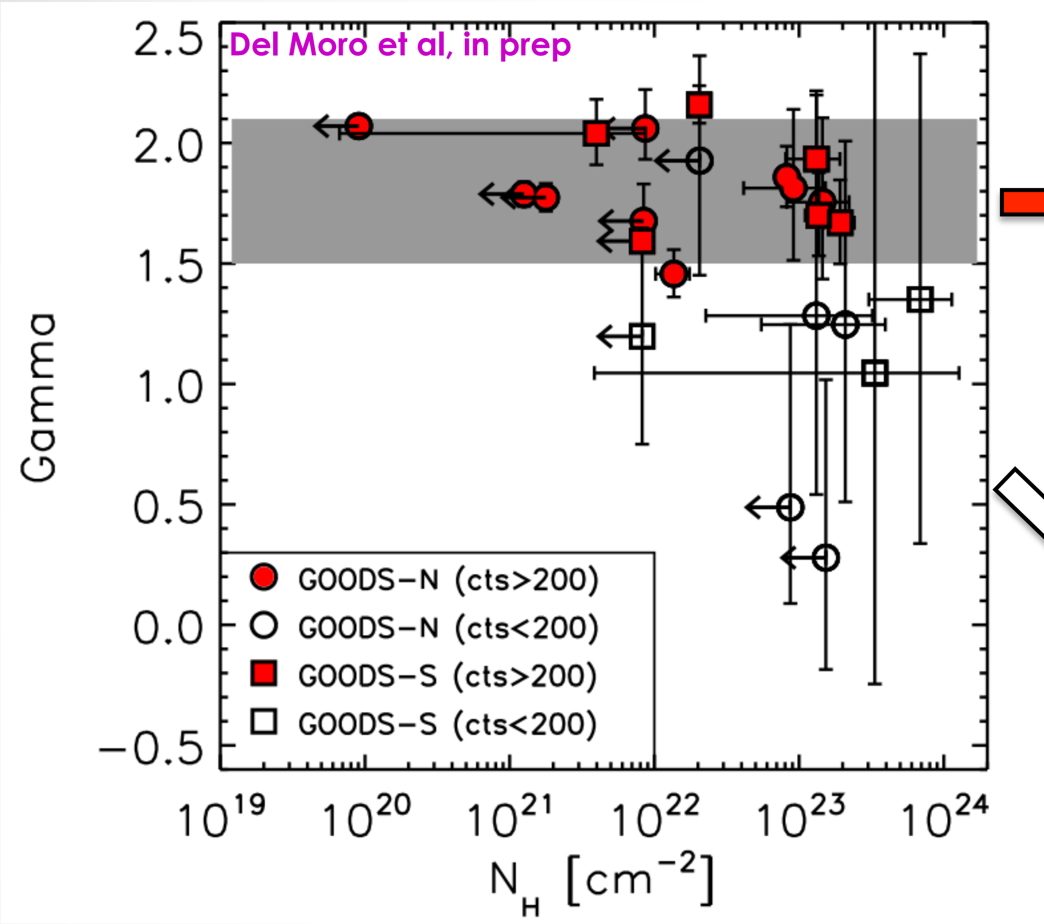
→ **Star formation rate (LIR, SFR)**

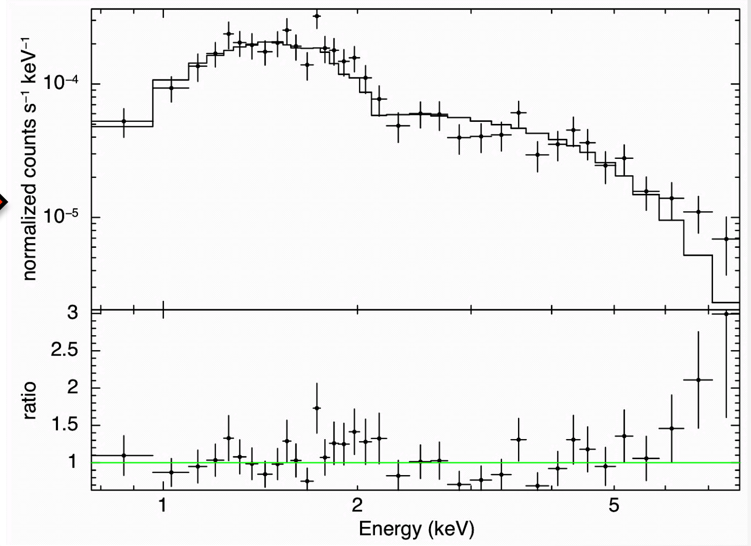
IR quasar sample selection

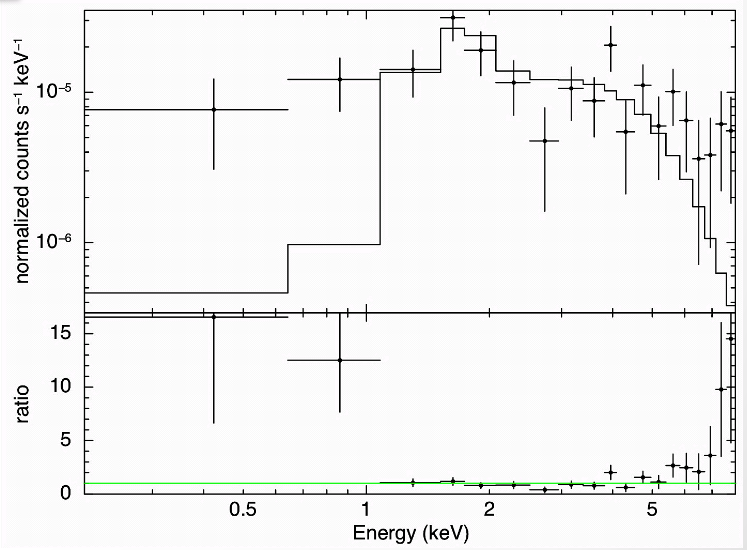


MIR luminosity log $L_{6um} \geq 44.8$ erg/s → $Lx > 10^{44}$ erg/s (Lutz+2004 relation)

X-ray spectral properties







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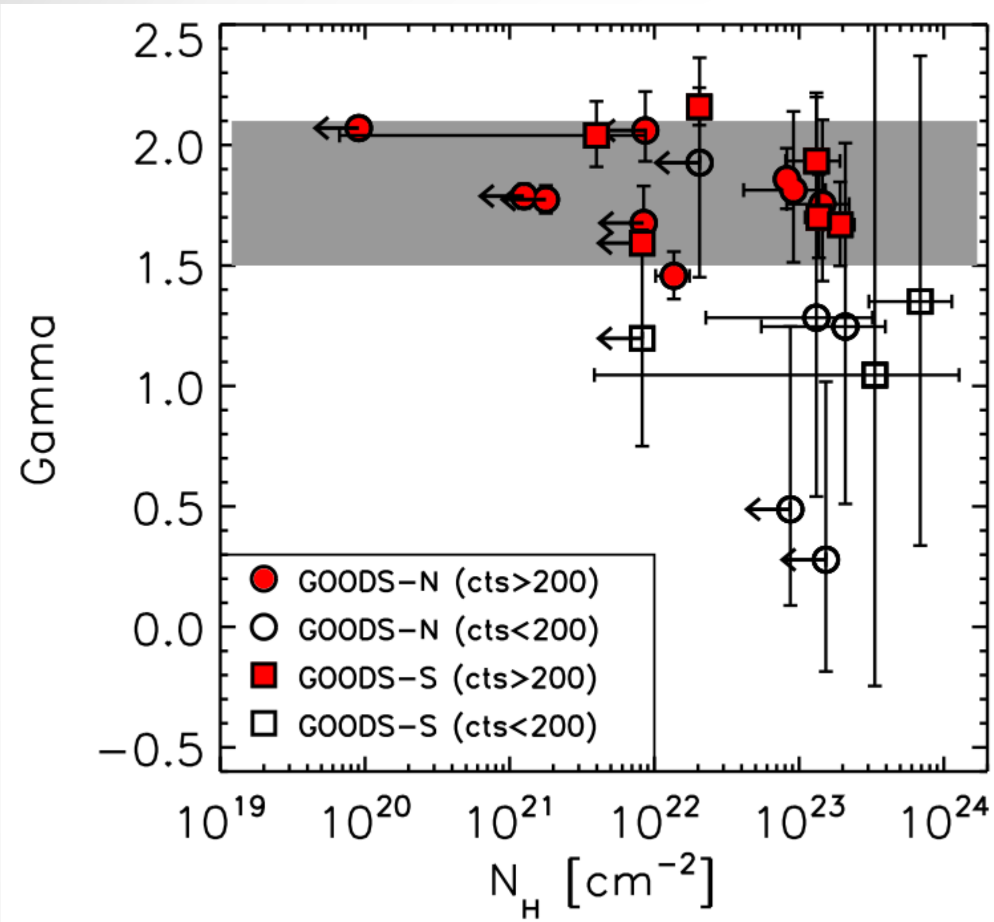
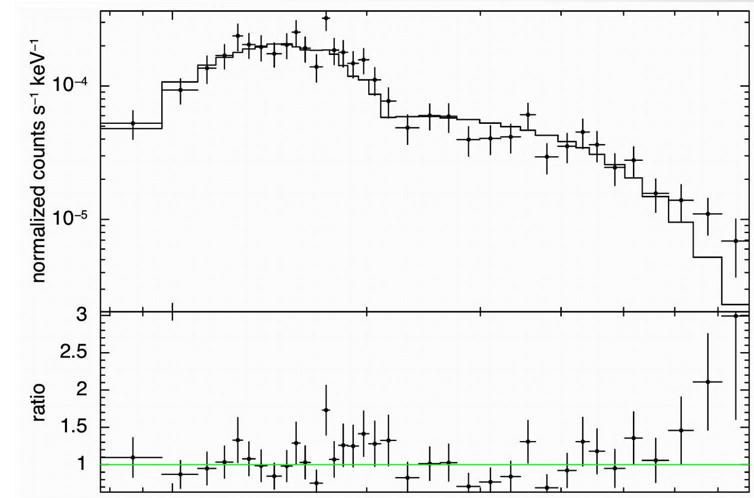
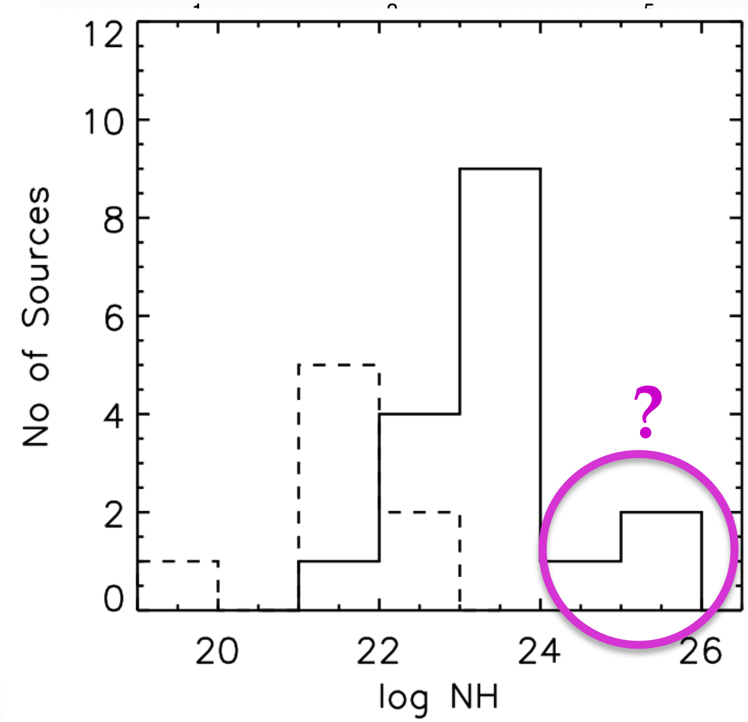
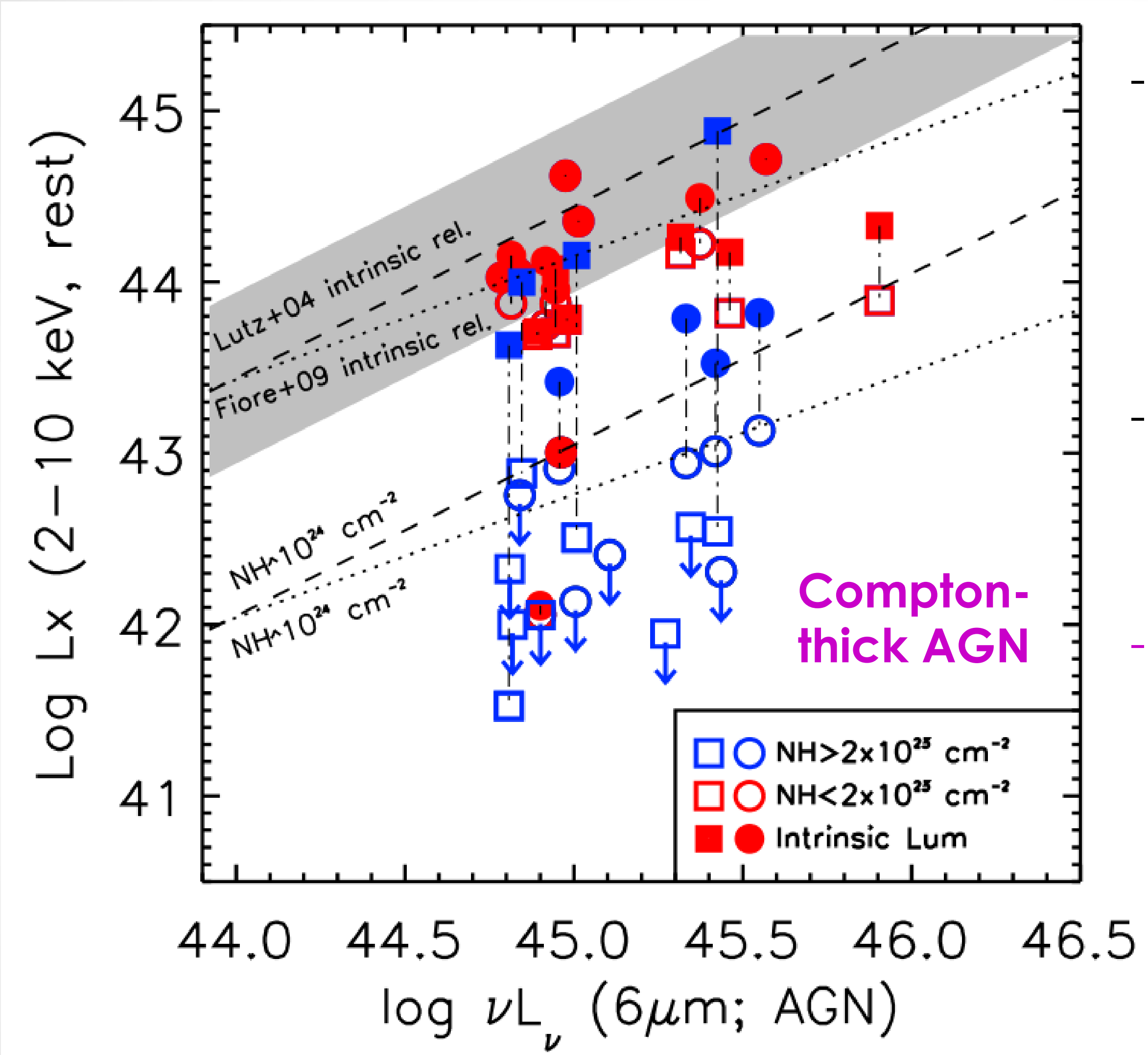




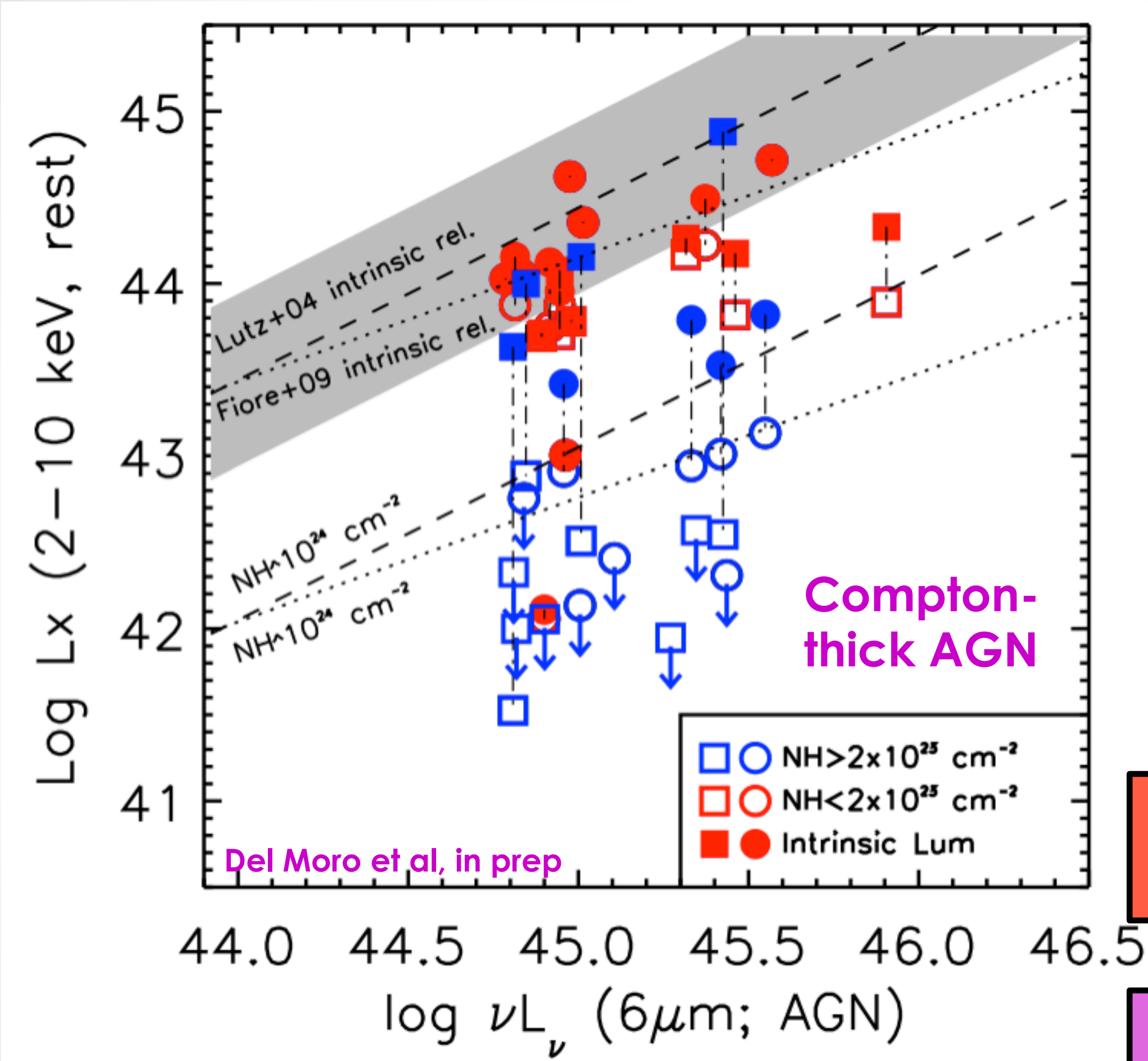


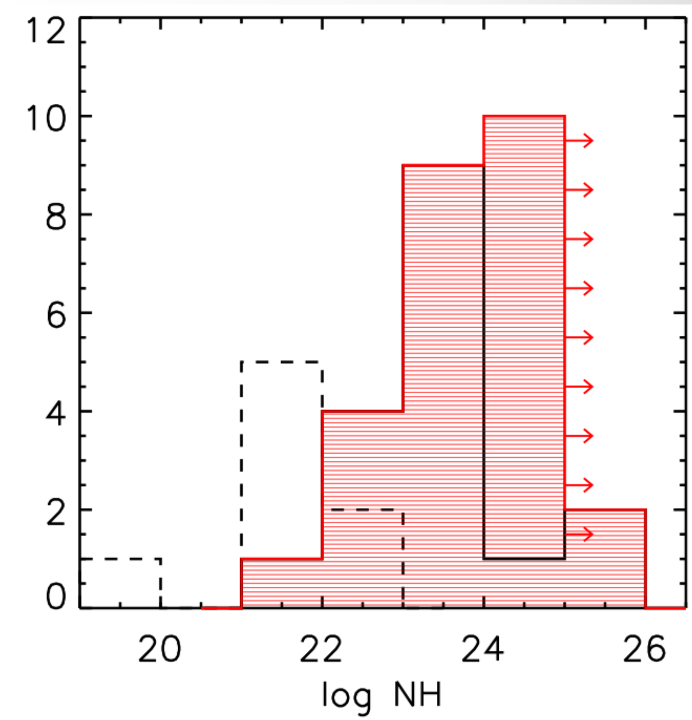
Observed and intrinsic AGN luminosity



- Unobscured and moderately obscured AGN (**NH<2x10^{23} cm^{-2}**) tent to follow the intrinsic IR-X-ray luminosity relation
- The heavily obscured sources lie well below (**NH>2x10^{23} cm^{-2}**)
- **~26% of the IR quasars are undetected in X-rays**

Observed and intrinsic AGN luminosity

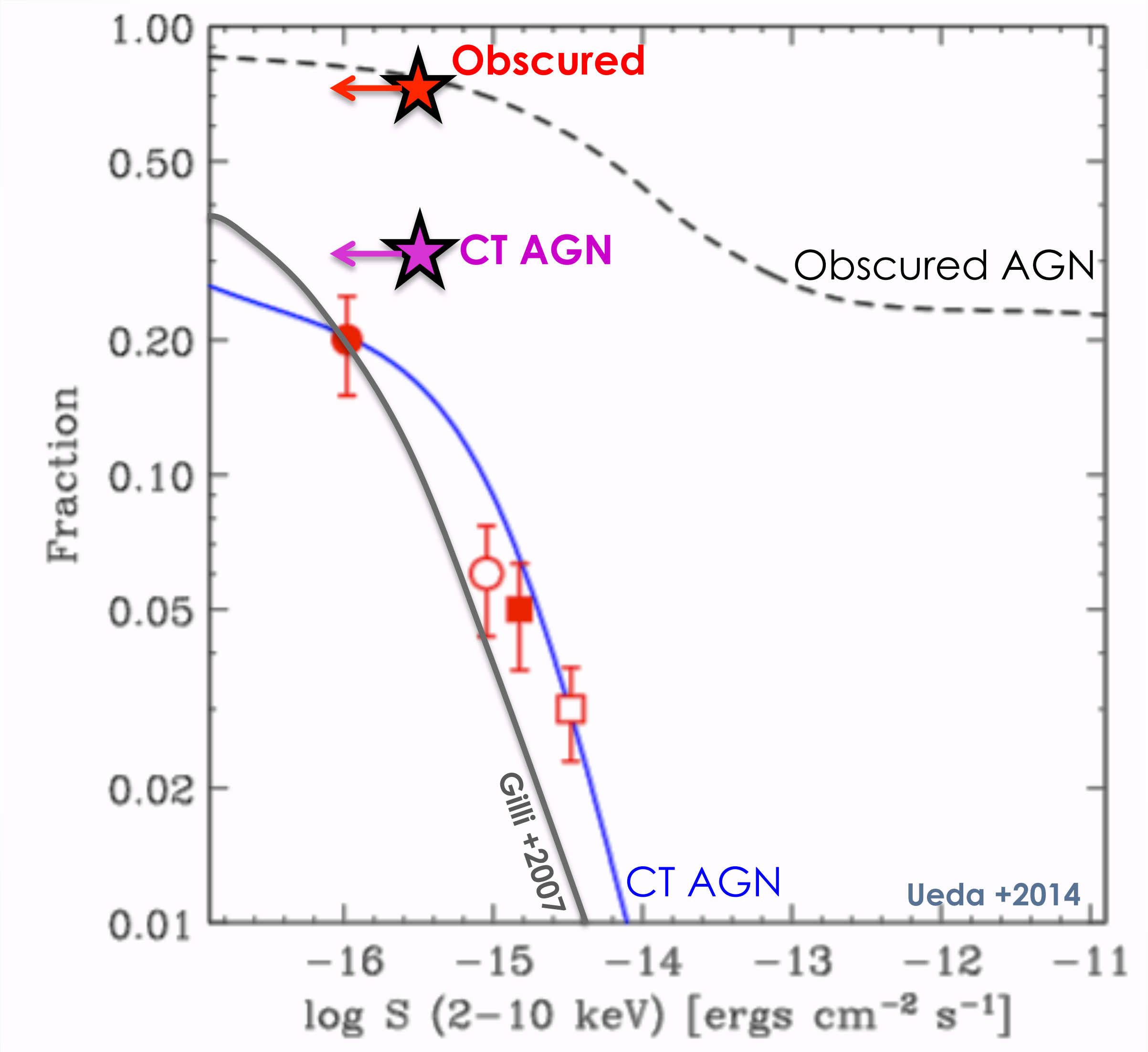




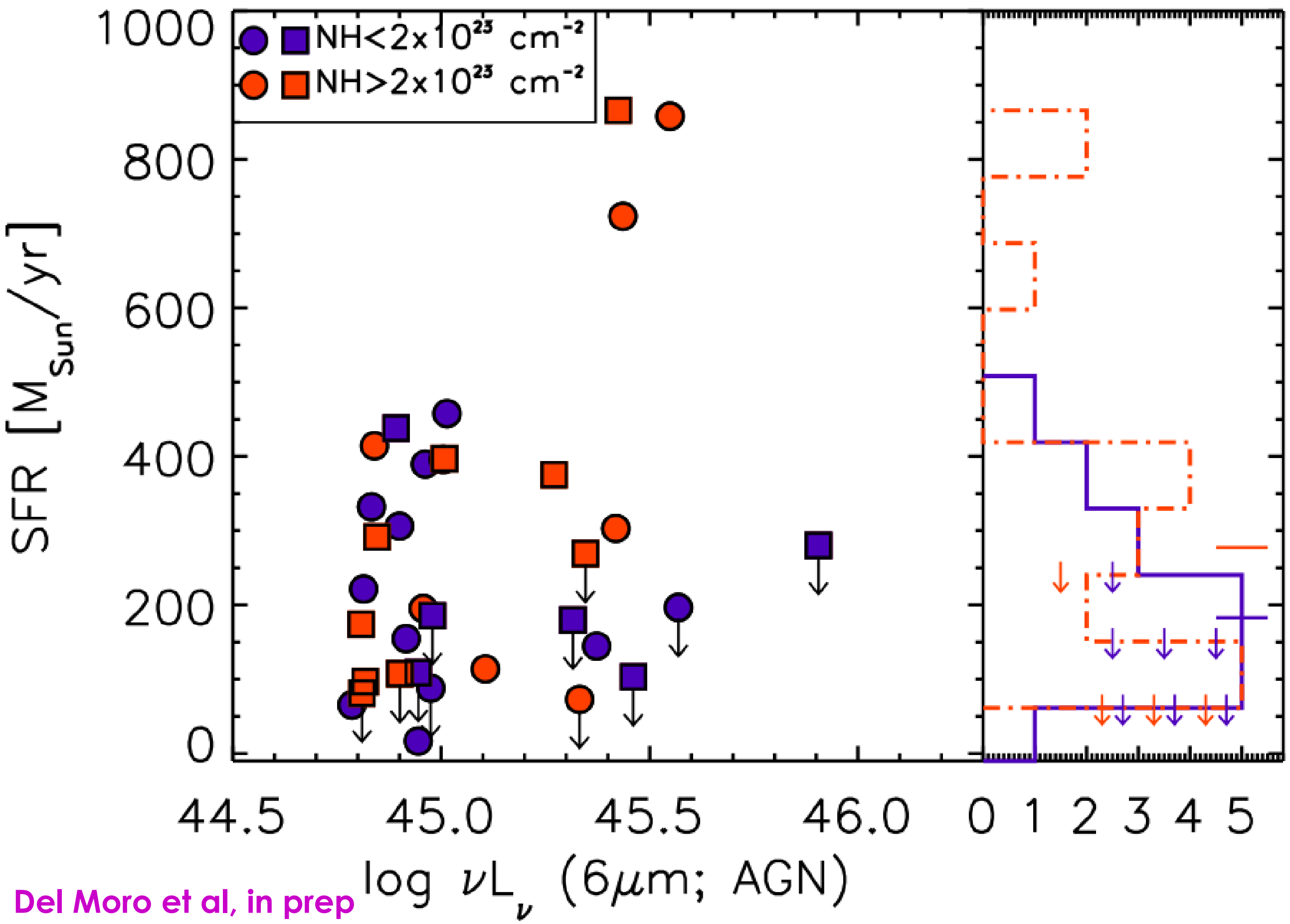
Total fraction of obscured quasars ~76%

35-40% Compton-thick candidates

Obscured AGN fraction



IR quasar star-formation rates

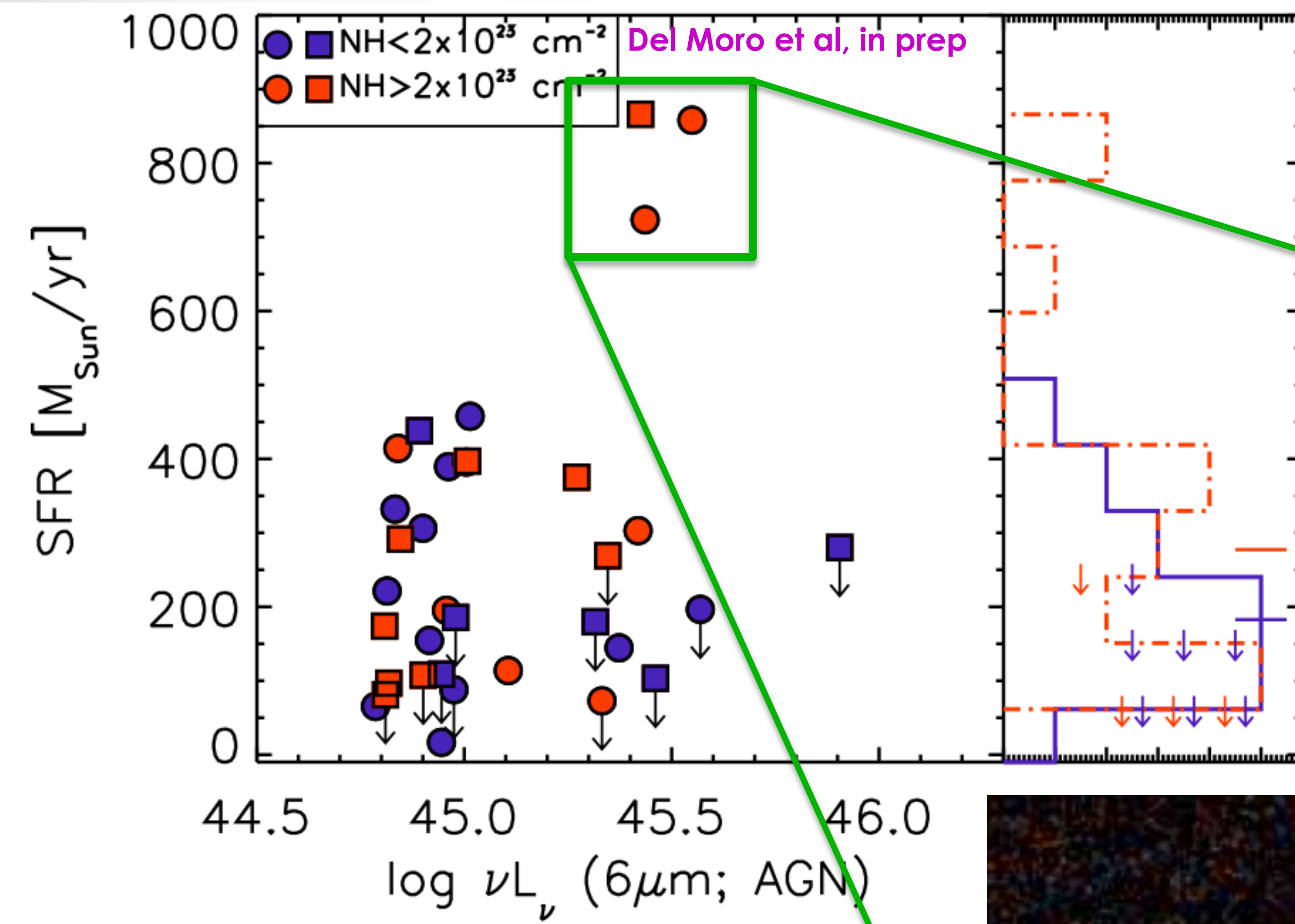


Del Moro et al, in prep

No significant difference in SFR between unobscured/ moderately obscured quasars and heavily obscured quasars

SFRs consistent with main sequence galaxies at z=1-3

IR quasar star-formation rates



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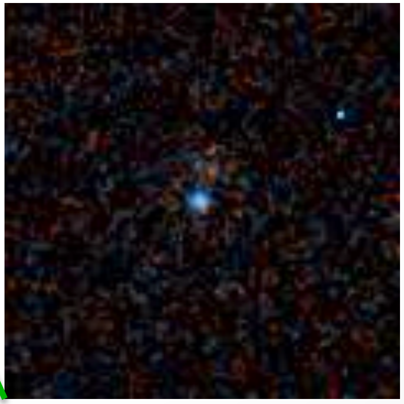
SF ith m g



Hard X-ray selection: NuSTAR

First focussing telescope sensitive at E>10 keV

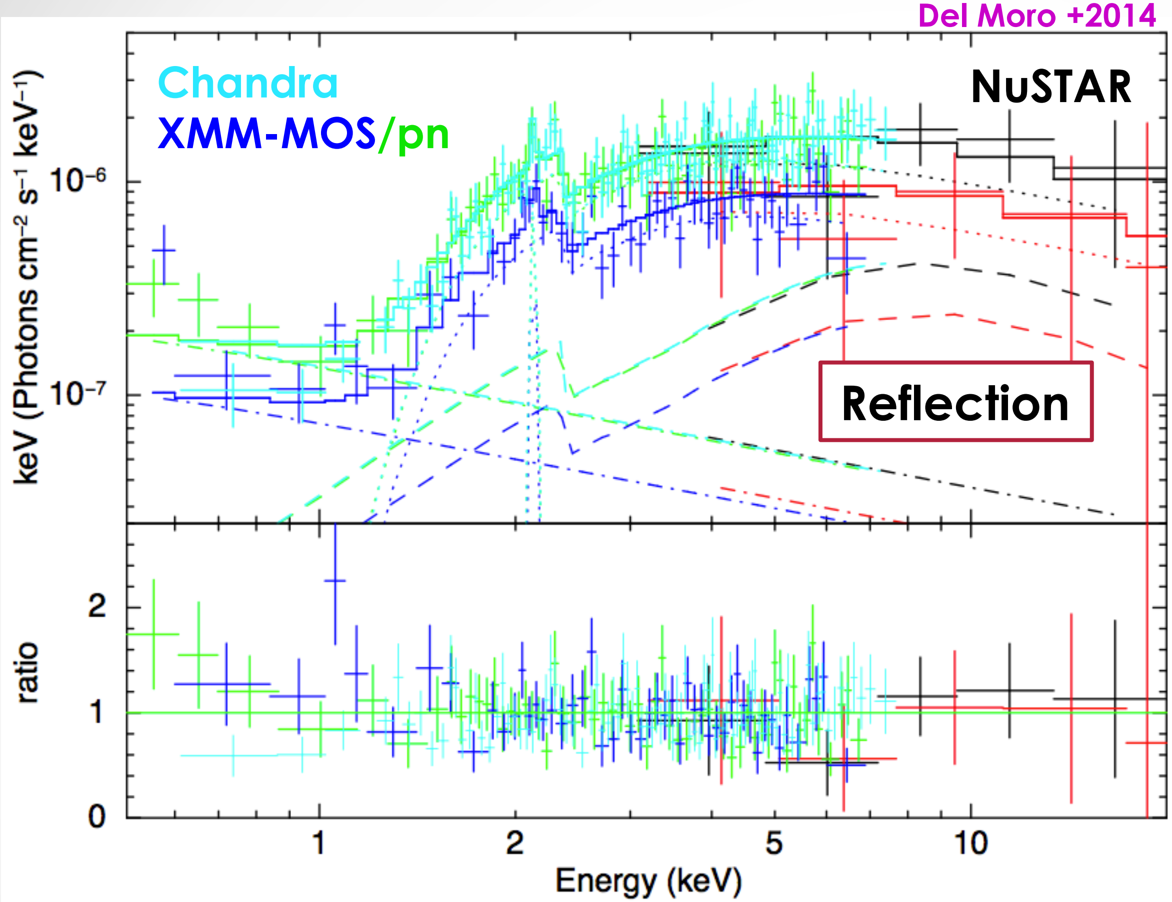
- ≈2 orders of magnitude more sensitive than previous-generation hard X-ray (E > 10 keV) observatories
- 1 order of magnitude higher angular resolution

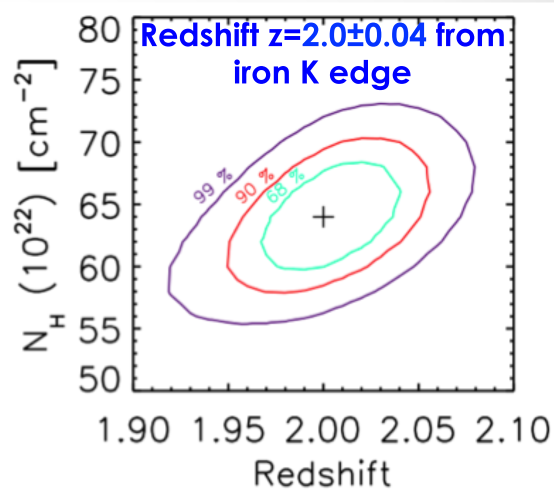
The NuSTAR extragalactic survey is designed to:

- Resolve XRB from direct detections and stacking Chandra/XMM sources
- Trace black-hole growth (AGN activity) almost independent of obscuration
- Define high-energy properties of AGNs – better define physical components and modelling of the XRB

Durham University   NuSTAR

NuSTAR J033202-2746.8



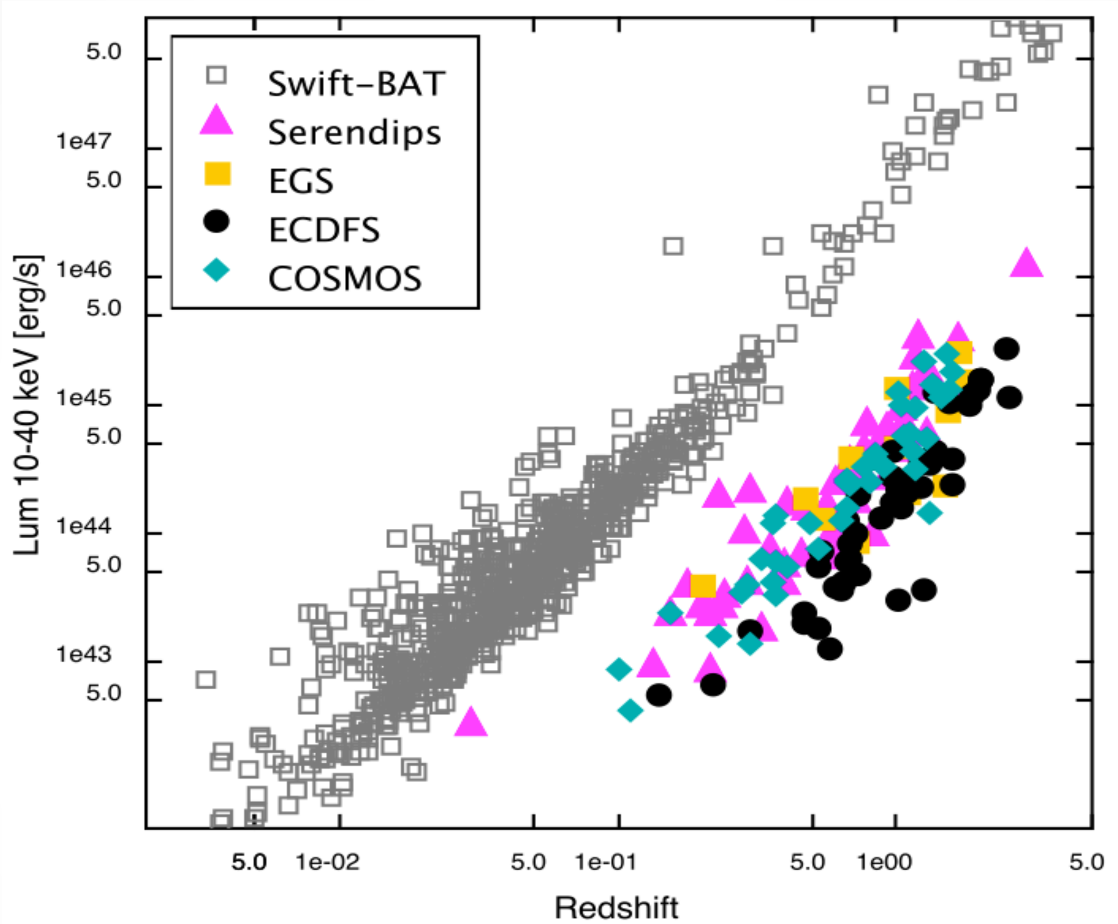


$N_H \approx 6 \times 10^{23}$ cm^{-2} → **2-3 times higher than that found from XMM/ Chandra alone**

$L_{10\text{-}40\ keV} \approx 6 \times 10^{44}$ erg/s (≈ 30% from Compton reflection)

Compton reflection: ***R* = 0.6 ± 0.4**

NuSTAR extragalactic survey population



Full spectral characterisation of NuSTAR survey sources is under way:
Alexander+2013, Del Moro+2014, Zappacosta+(in prep), Del Moro+(in prep),
See also L. Zappacosta's talk

Durham University NuSTAR

Summary

- Population of IR bright quasars at z≈2 → >3 times more obscured AGN than unobscured AGN. ~30% are X-ray undetected
- ≈30-40% are likely to be Compton-thick AGN: higher fraction than typically found in X-ray selected samples
- SFR of heavily obscured AGN not significantly different from unobscured AGN
- Hard X-rays (E>10 keV)are essential to fully characterise intrinsic spectral properties
- NuSTAR provides information at E>10 to directly constrain the broad-band X-ray spectral properties of AGN also for heavily obscured quasars → better understanding of X-ray background composition at its peak E≈30 keV