Survival of the obscuring torus in the most powerful active galactic nuclei

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Thanks to: **F.J. Carrera, X. Barcons, A. Alonso-Herrero**, A. Hernán-Caballero, A. Blain, A. Caccianiga, T. Miyaji, R. Della Ceca, A. Asensio-Ramos, C. Ramos-Almeida

Big question: What is the intrinsic fraction of luminous type-2 AGN?

Most AGN searches find that ***the obscured AGN fraction decreases with increasing luminosity***

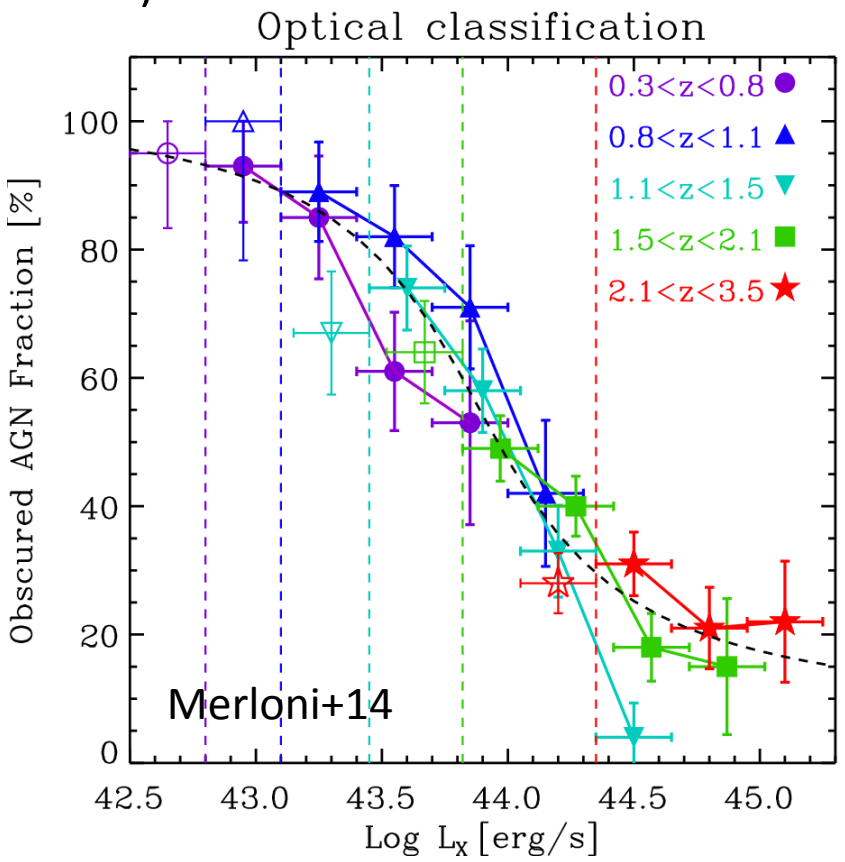
(e.g. Hasinger+08; Della Ceca+08; Ebrero+09; Lusso+13; Merloni+14; Ueda+14; Buchner+15)

Receding torus models (Lawrence+91):

The covering factor of the torus decreases with increasing AGN luminosity

Results not free from controversy:

Reyes+08; Lawrence+10; Mayo+13; Sazonov+15; Georges+16; Mateos+16; Netzer+16; Stalevski+16

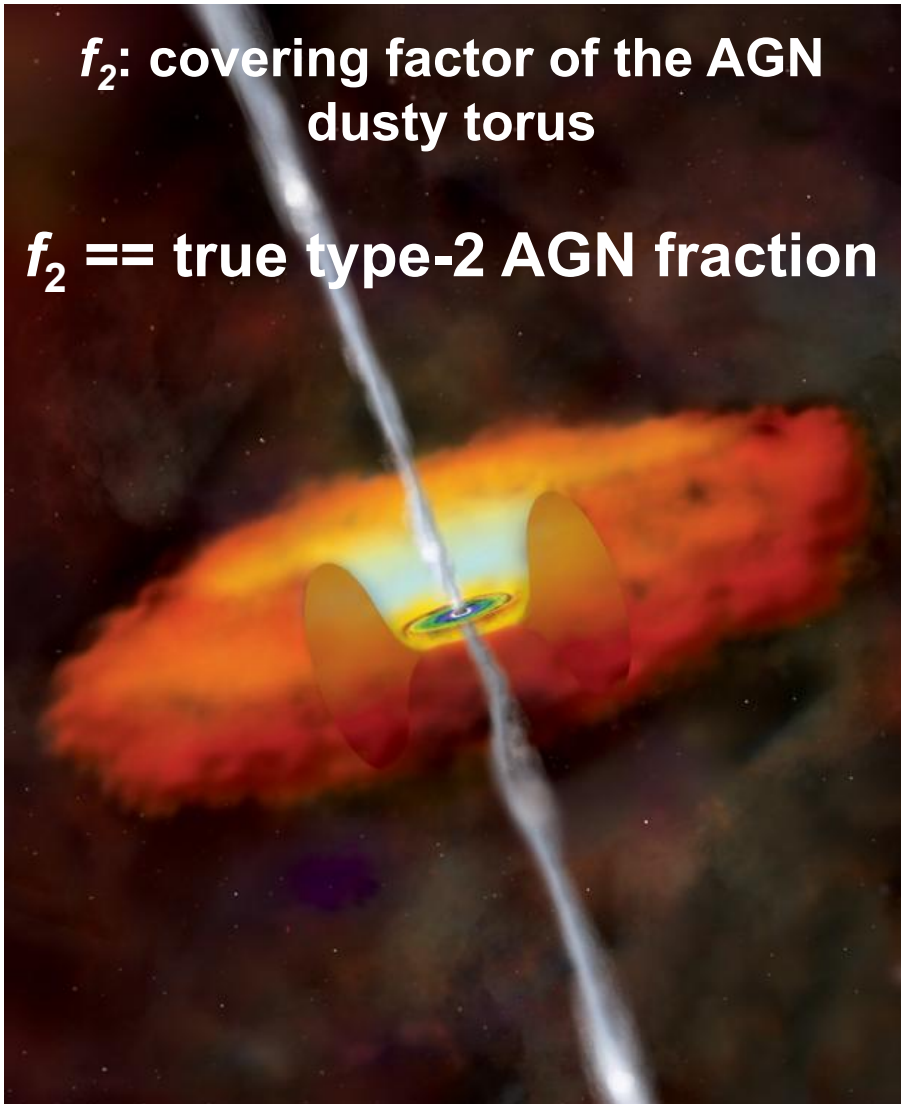


Our study:

Luminosity dependence of the intrinsic fraction of type-2 AGN

Novel technique

We used the **geometrical** covering factors of AGN tori to determine the intrinsic **type-2** AGN fraction



AGN sample

The Bright Ultra-hard XMM-Newton Survey (BUXS; Mateos+12)

- Complete flux-limited sample: $f_{4.5\text{-}10\ keV} > 6\text{x}10^{-14}$ **erg cm^{-2} s^{-1}**
- ***>98% spectroscopic identification rate***

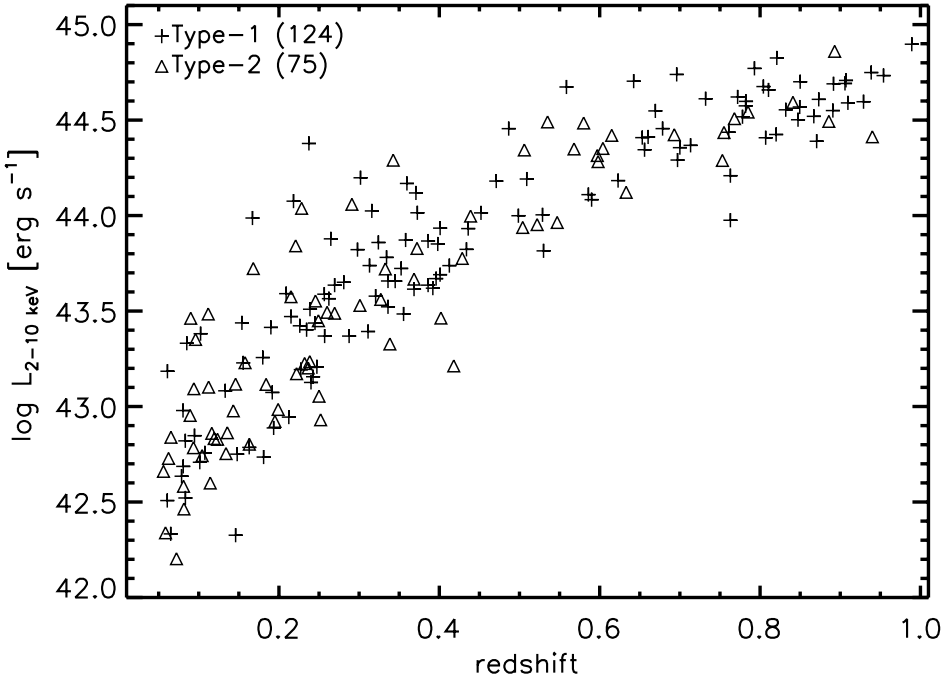
  162 type 1 AGN (+Sy1.8-1.9); **90** type 2 AGN
- ***We know f_2 for 99% of objects***
- ***Good quality X-ray spectra for all sources***

  robust estimates of $L_{2\text{-}10\ keV}$

199 AGN with:

0.05<z<1

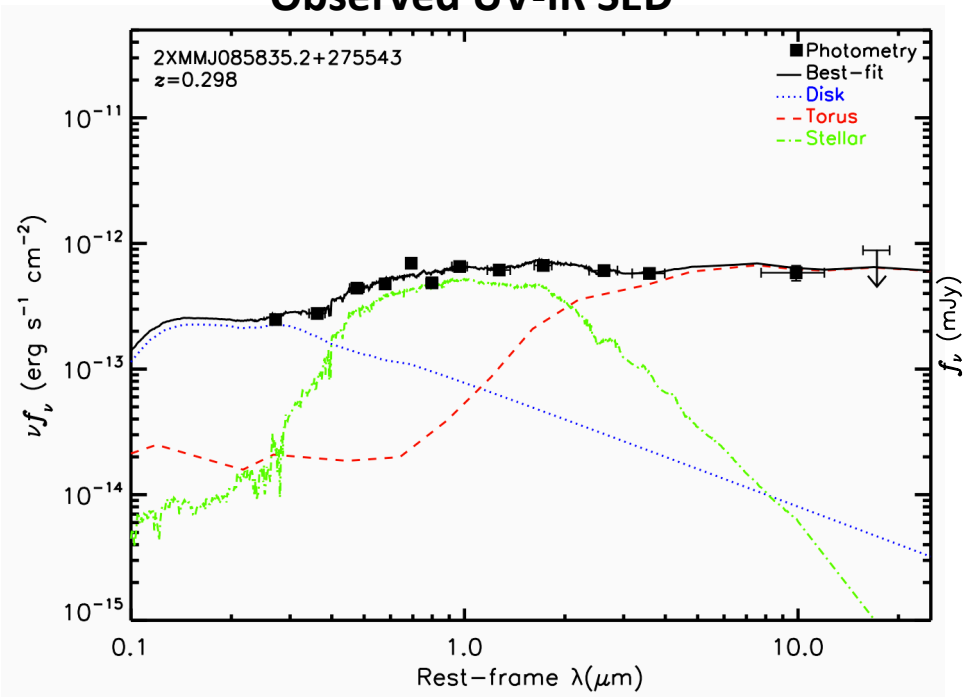
$L_{2\text{-}10\ keV}$: 10^{42}-10^{45} erg s^{-1}



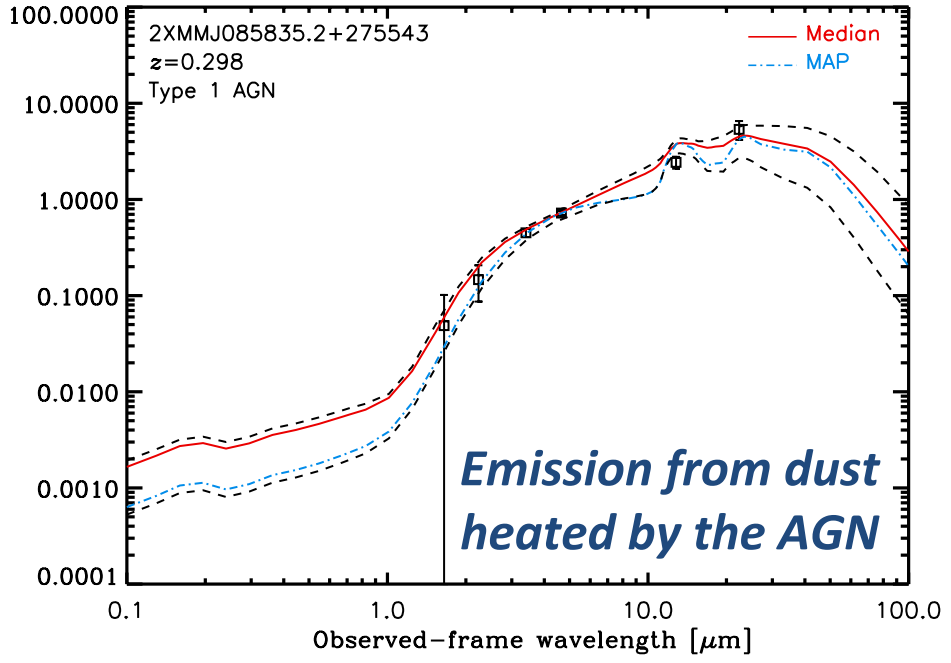
Isolating the torus emission (Mateos+15)

UV-to-mid-IR SEDs (SDSS, 2MASS, UKIDSS, WISE) corrected for contamination from AGN hosts and accretion disk emission

Observed UV-IR SED



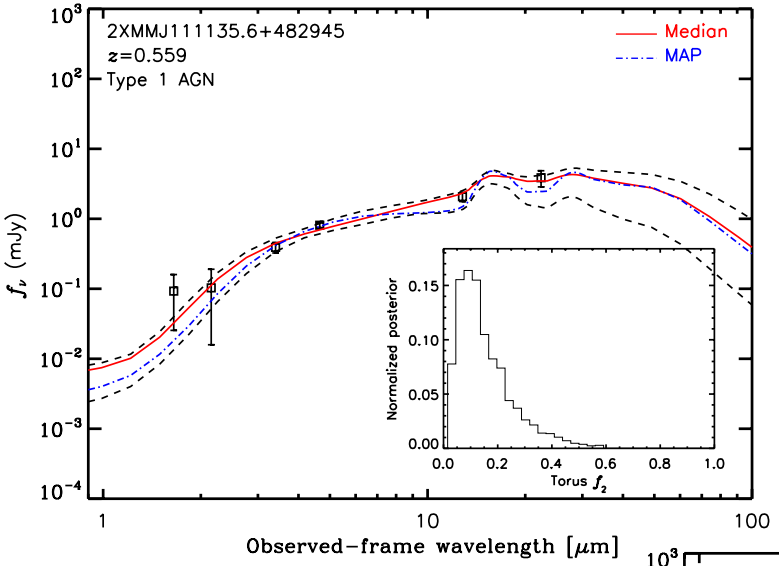
Torus IR SEDs: rest-frame 1-20 µm

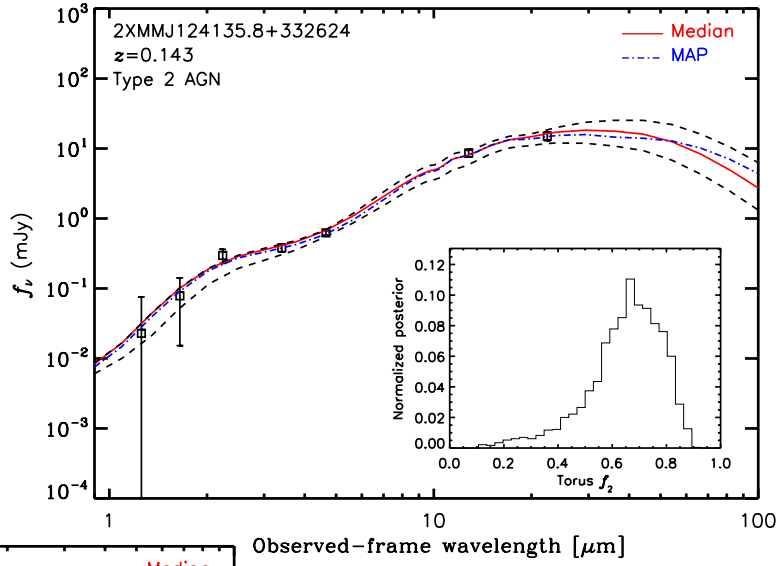


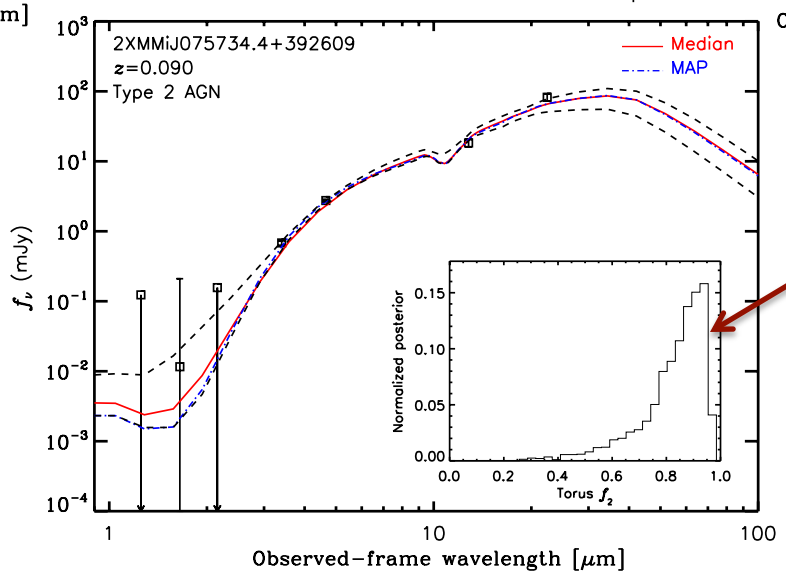
SED fitting with BayesCLUMPY (Mateos+16)

Nenkova+08 radiative transfer torus models

Bayesian inference tool: **BayesCLUMPY** (Asensio Ramos & Ramos Almeida +09, +12)







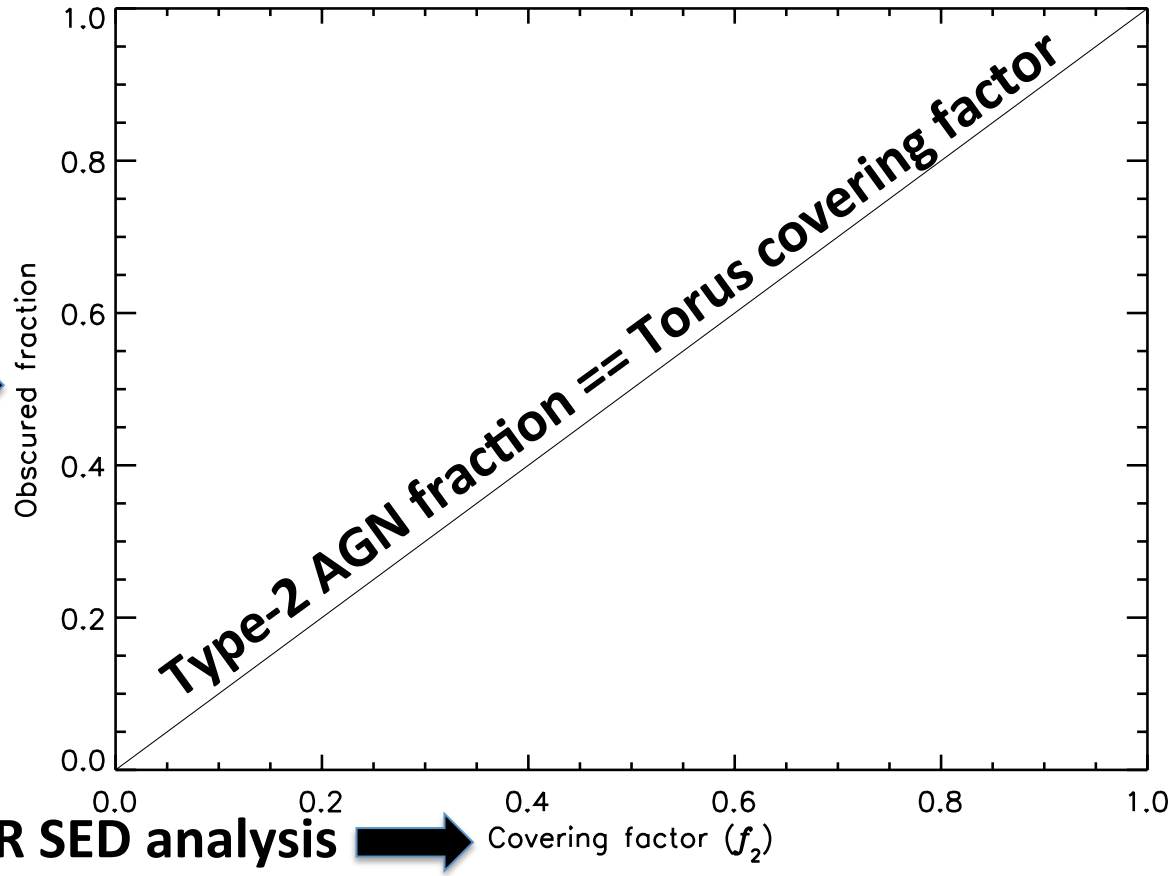
Posterior distributions of f_2 for each AGN

Observed type-2 AGN fraction vs. f_2

f_2 = geometrical covering factor of the torus

f_2 combined over the total AGN population == intrinsic type-2 AGN fraction

Optical class

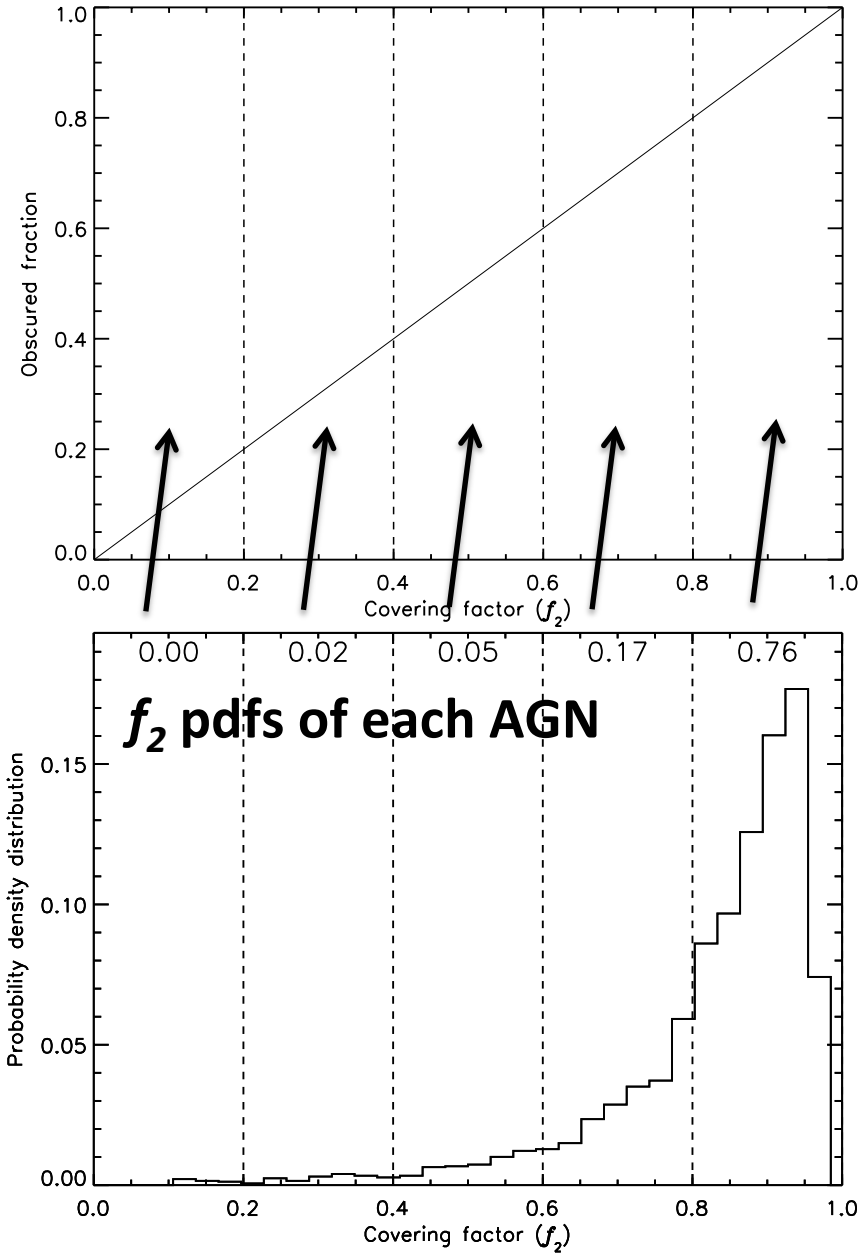


IR SED analysis

Observed type-2 AGN fraction vs. f_2

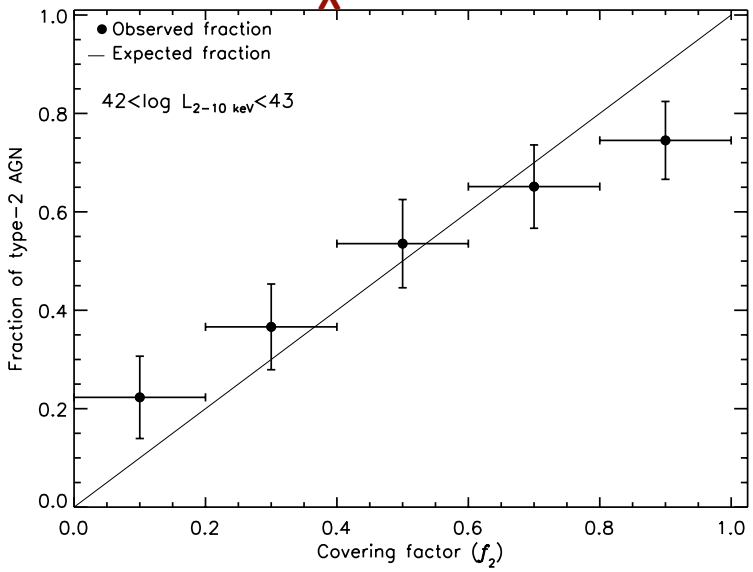
For each f_2 bin:

$$F_{obs} = \frac{\sum 2}{\sum 1 + \sum 2}$$

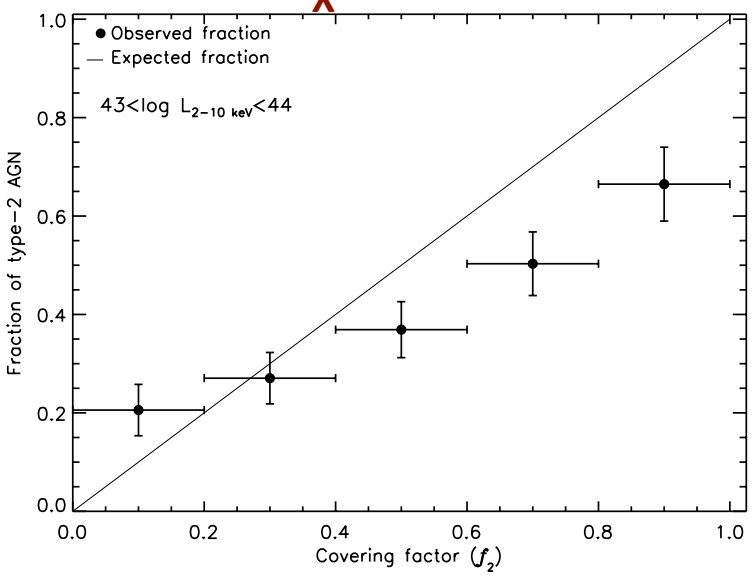


Three L_X bins

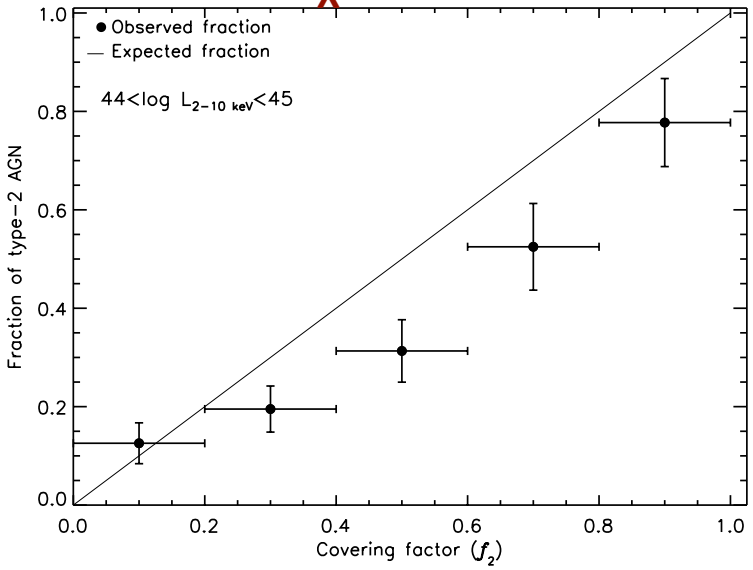
L_X=42-43



L_X=43-44



L_X=44-45



There are not enough luminous type-2 AGN with high f_2

Some must have escaped X-ray detection

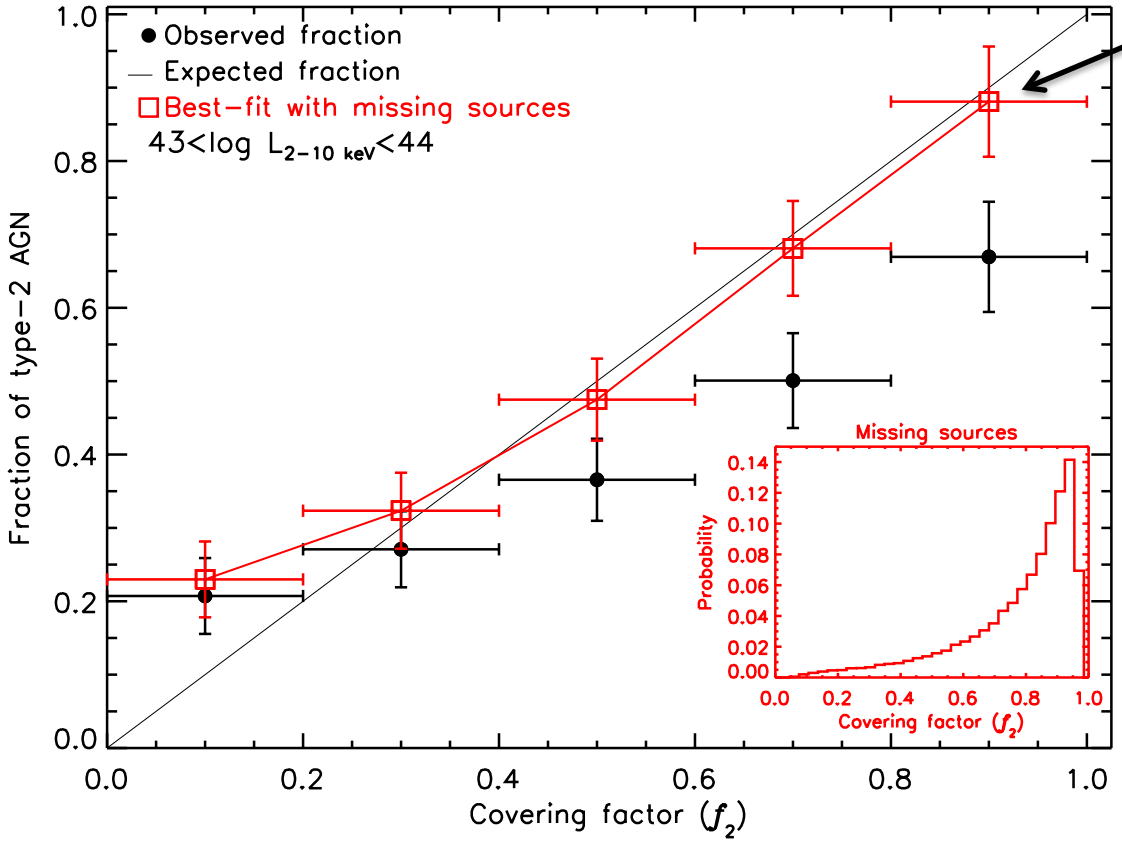
Number of objects missed in X-rays

- The AGN missed are all type-2 AGN

Highly absorbed + Compton-thick

- Stacked f_2 distribution for highly absorbed type-2 AGN in BUXS represents well that of the objects missed in X-rays

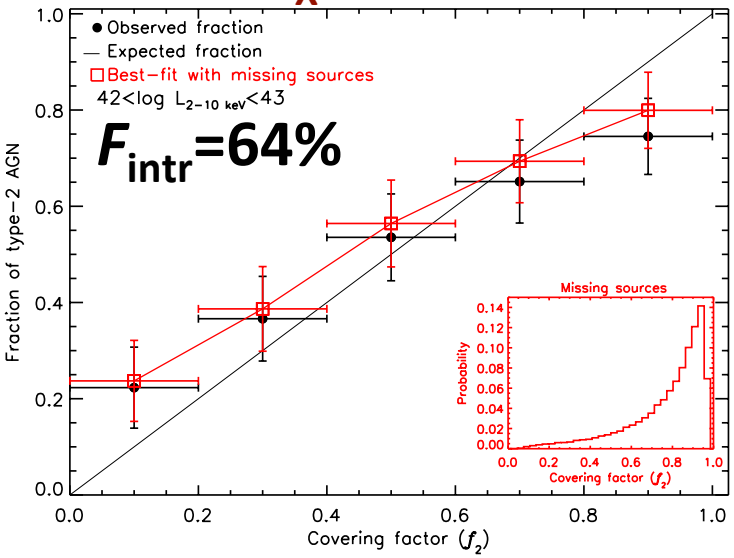
$$F_{intr} = \frac{\sum 2 + N_2 \times F_{CT}}{\sum 1 + \sum 2 + N_2 \times F_{CT}}$$



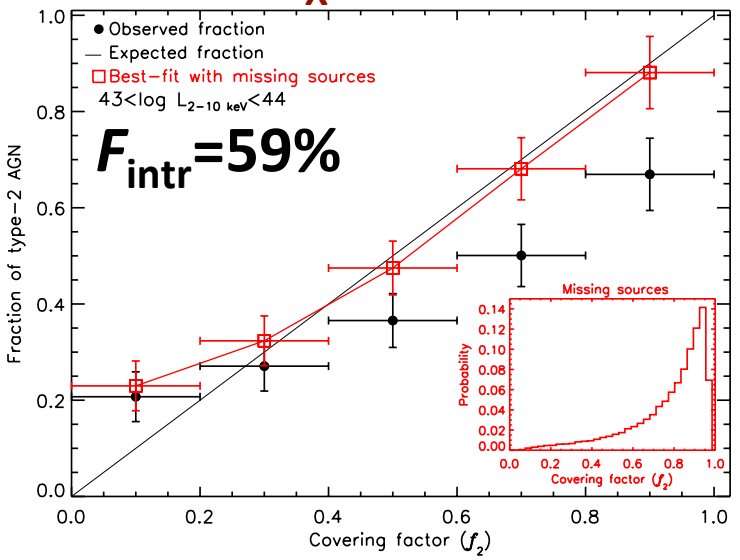
f_2 distribution for the AGN missed in X-rays

Number of objects missed in X-rays

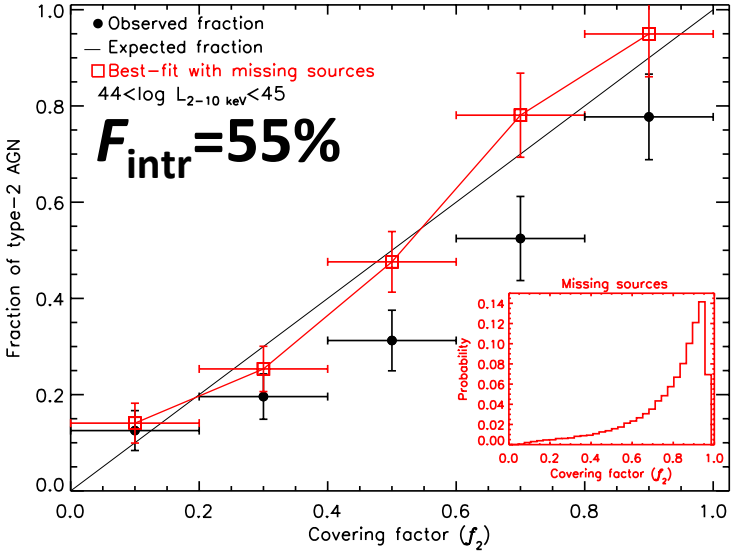
L_X=42-43



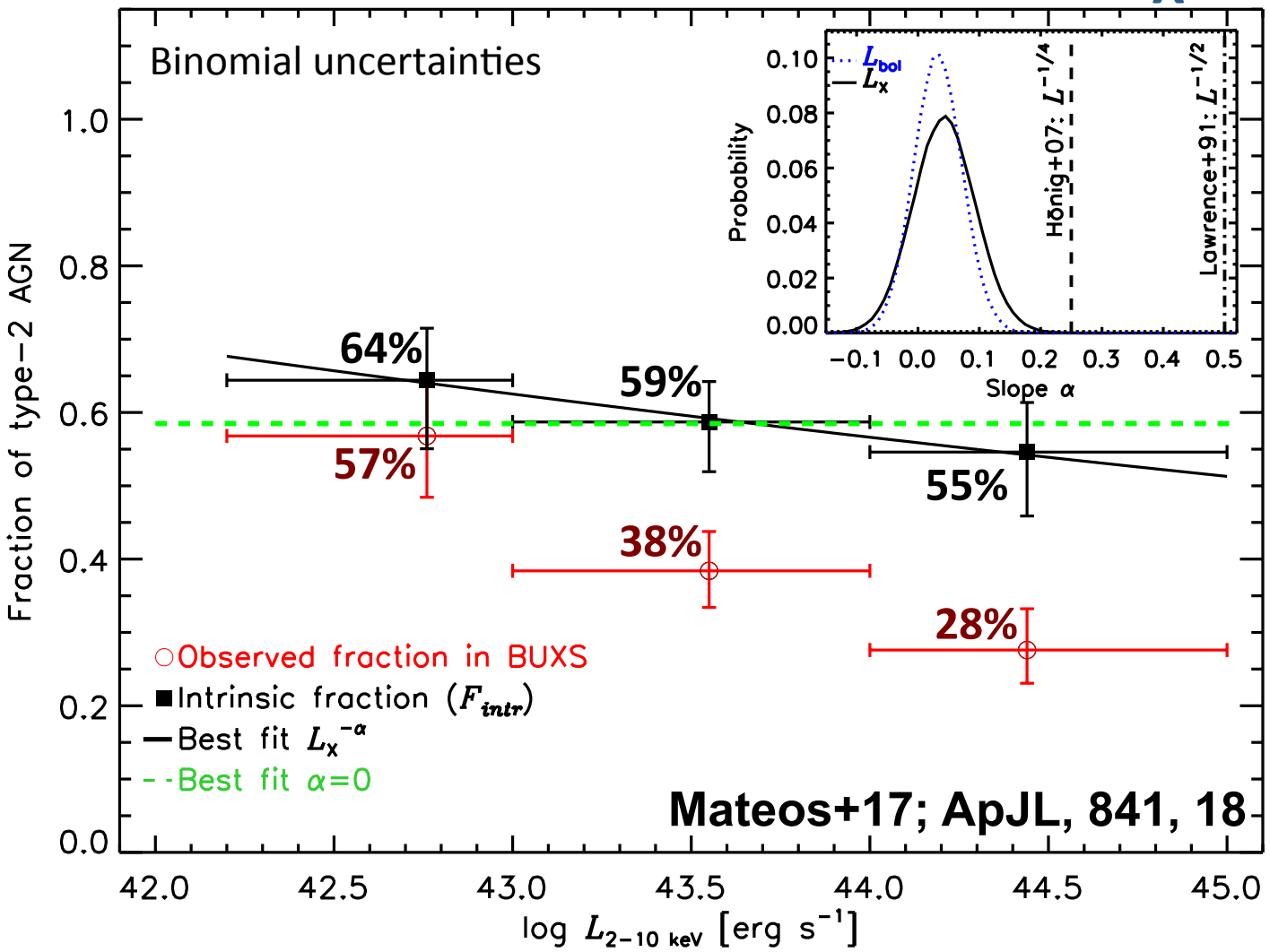
L_X=43-44



L_X=44-45

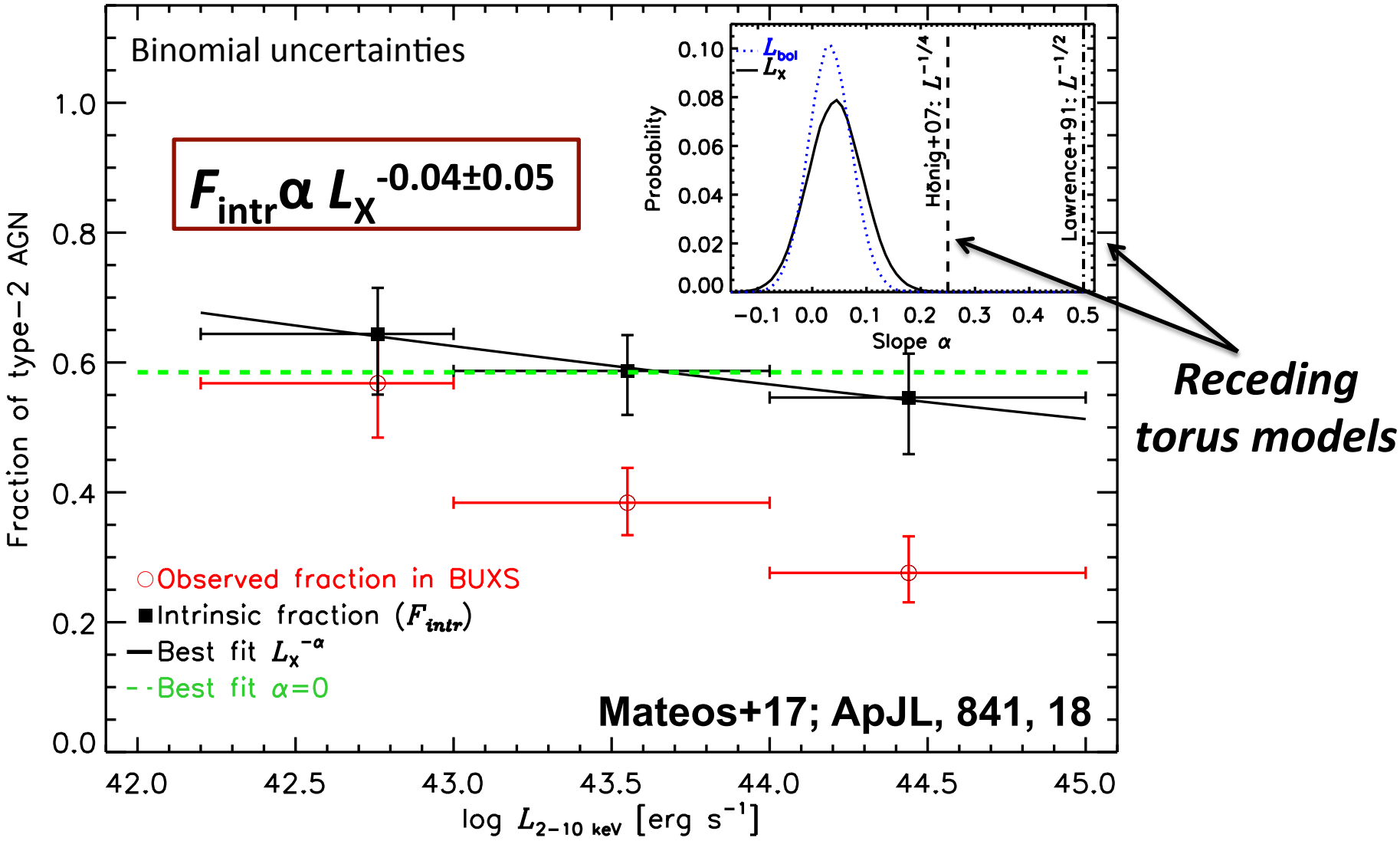


Type-2 AGN fraction vs. L_X



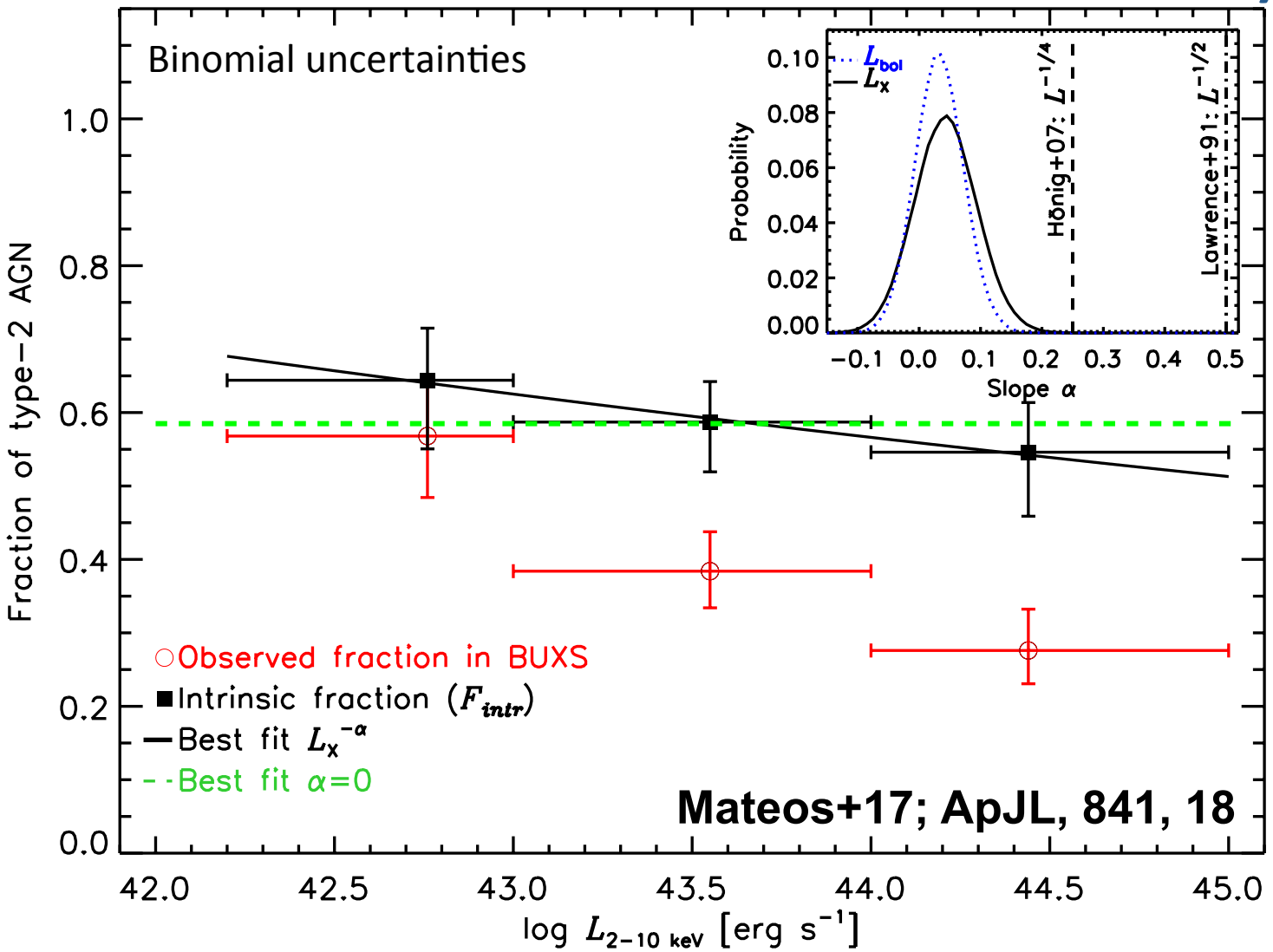
The majority of luminous type-2 AGN reside in highly obscured nuclear environments but most of them have escaped detection

Comparison with receding torus models



Our results clearly disagree with the expectations from receding torus models

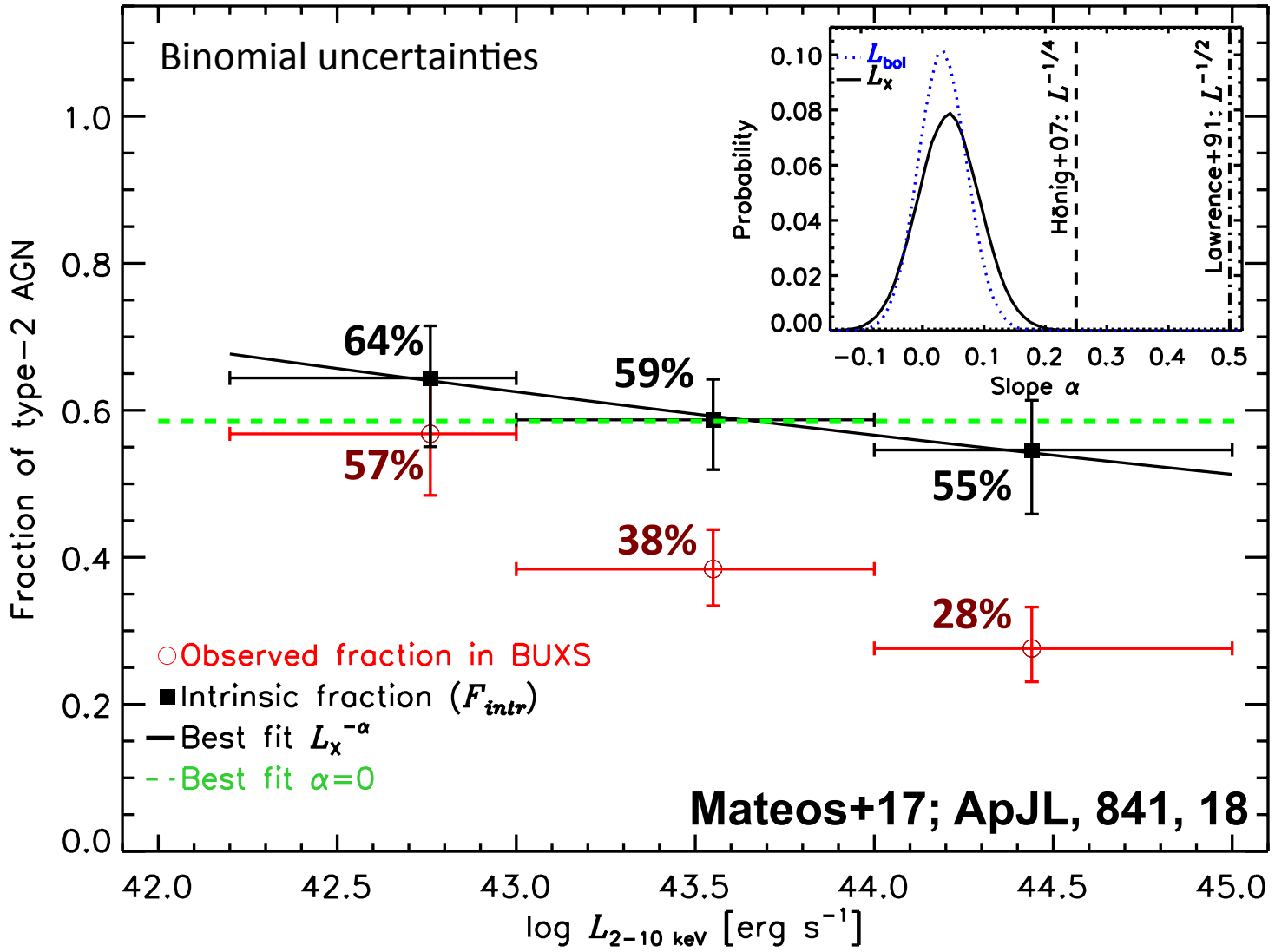
Type-2 AGN fraction vs. L_X



F_{intr}=58±4%

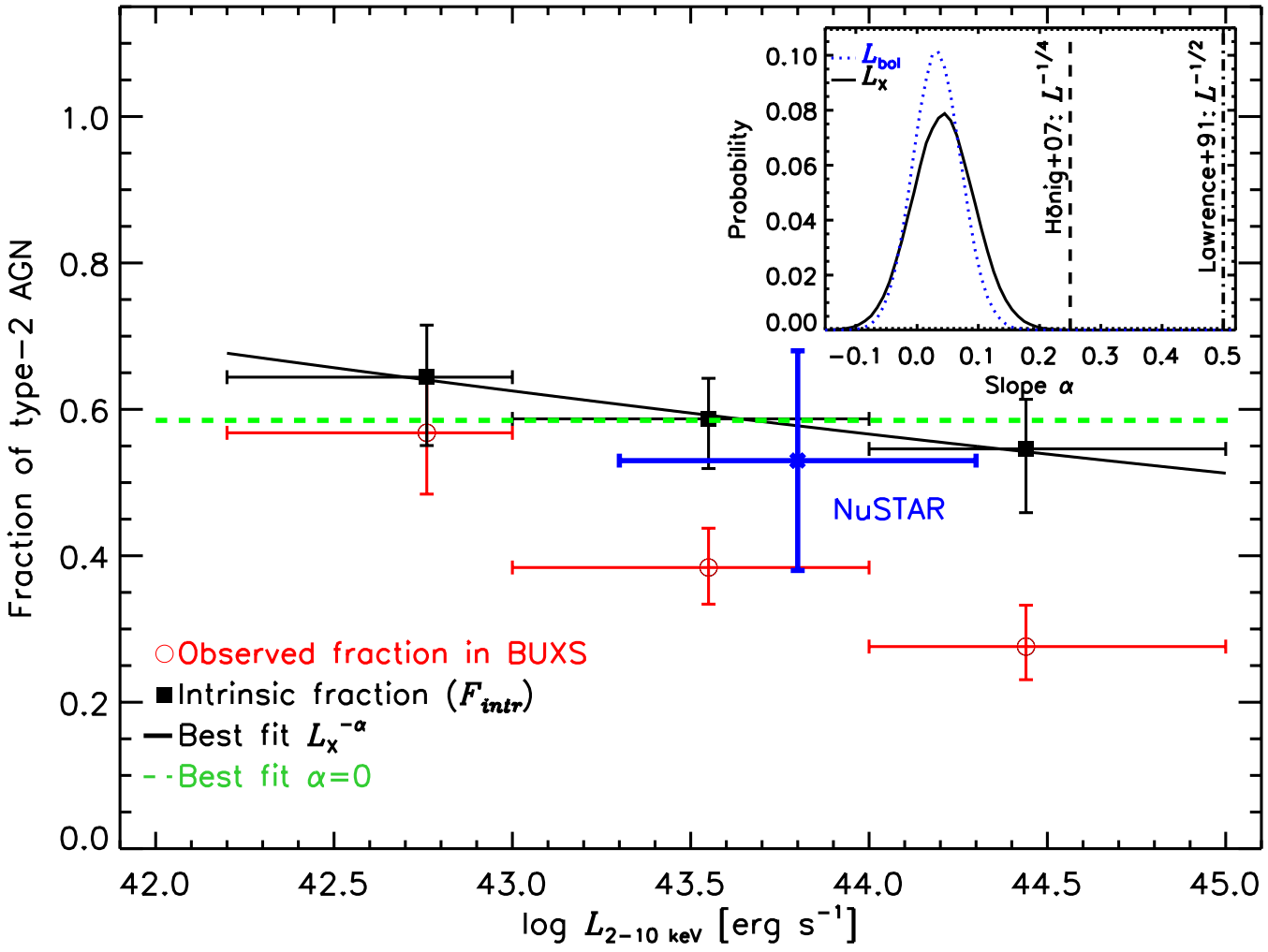
When the "missing" objects are included, the luminosity dependence of the type-2 AGN fraction disappears

Compton-thick AGN fraction



Compton-thick AGN account at most for 37% of the total population

Comparison with >10 keV AGN surveys



Our finding are consistent with first results from the NuSTAR serendipitous survey (Lansbury+17)

Summary

- We reveal a population of X-ray undetected type-2 AGN with high-covering factor tori
  - ***These are increasingly numerous at higher luminosities***

- When these ”missing” objects are included, the luminosity dependency of the obscured AGN fraction disappears
  - ***Clear disagreement with predictions from receding torus models***
  - ***The intrinsic obscured AGN fraction is ~58%***
  - ***Compton-thick AGN account at most for 37% of the total population***

The majority of rapidly-accreting SMBH reside in highly obscured nuclear environments but most of them remain elusive to contemporary <10 keV wide-area X-ray surveys