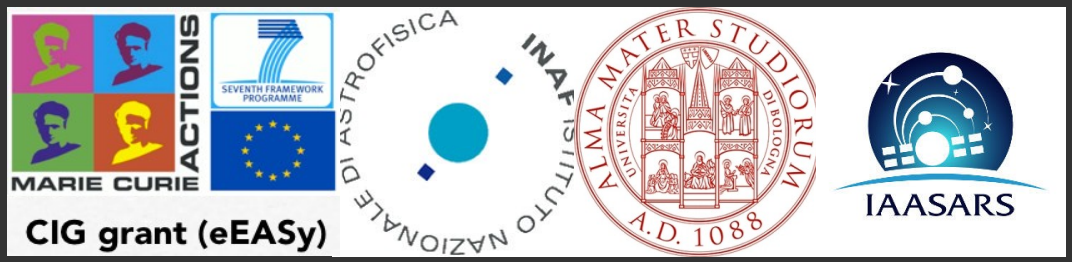
# Compton Thick AGN in multi-wavelength surveys

G. Lanzuisi

A. Comastri, M. Brusa, C. Vignali, R. Gilli, M. Mignoli,
K. Iwasawa, P. Ranalli, I. Georgantopoulos, T. Akylas and others
+ COSMOS team and XMM-CDFS team



# Outline

- Why bother about CT AGN?
- Different multi-λ selection of CT AGN at high z
- New results from X-ray selection
- Conclusions

# Why bother about CT AGN?

**Two "indirect" evidences that are common (at all z):**

- **X-ray Background**
- **Continuity equation (Soltan argument)**

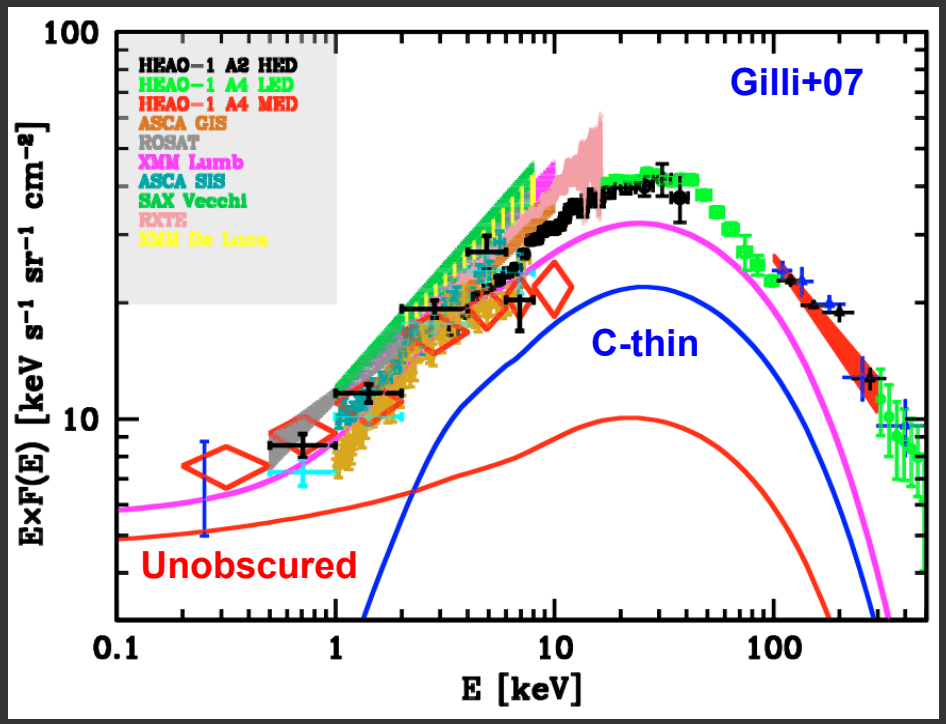
**One "direct" evidence that are common (at low z):**

- **Large fraction of local CT AGN**

**One prediction from galaxy formation models (at high z):**

- **Key phase in SMBH/galaxy evolution?**

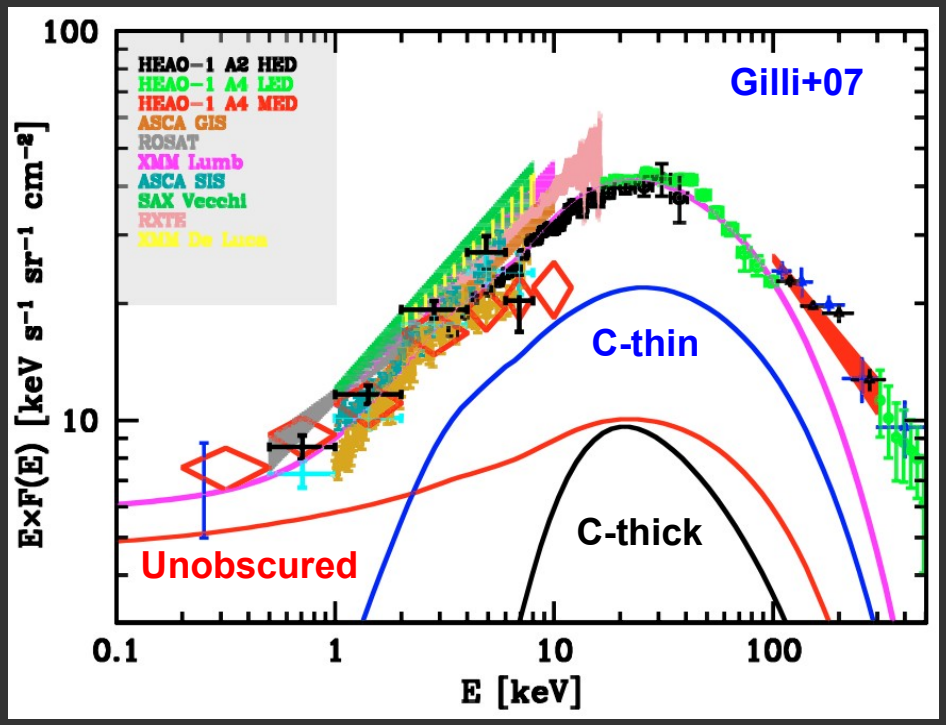
# X-ray Background




Comastri+95, Ballantyne+11, Ueda+14

- CT needed to reproduce the **XRB**

# X-ray Background

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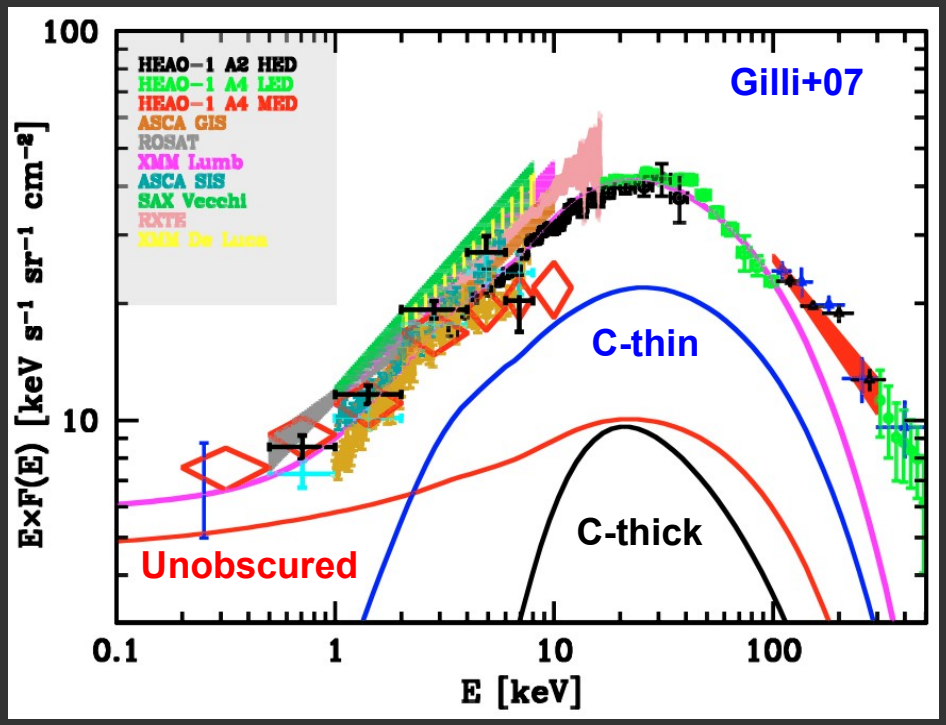


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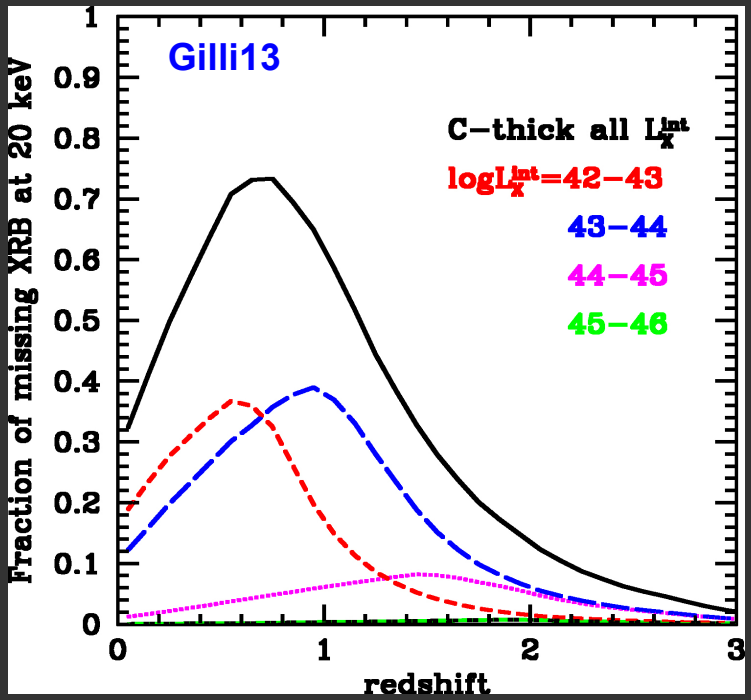

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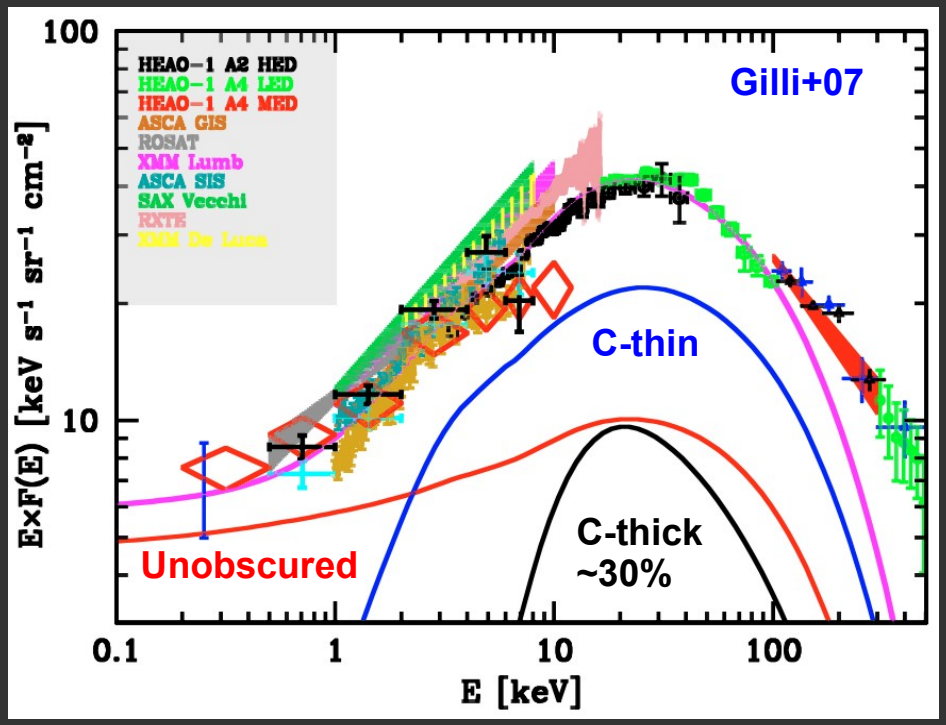


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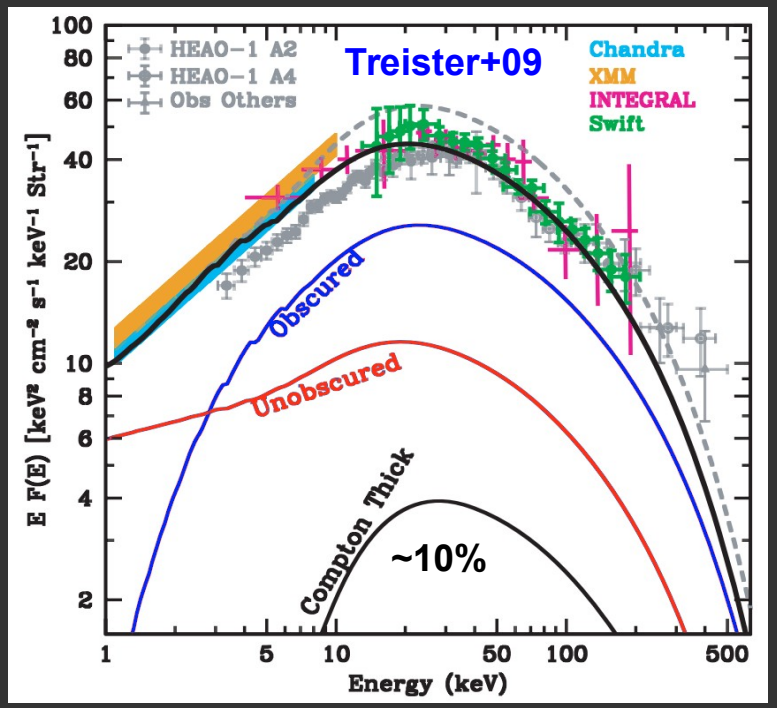


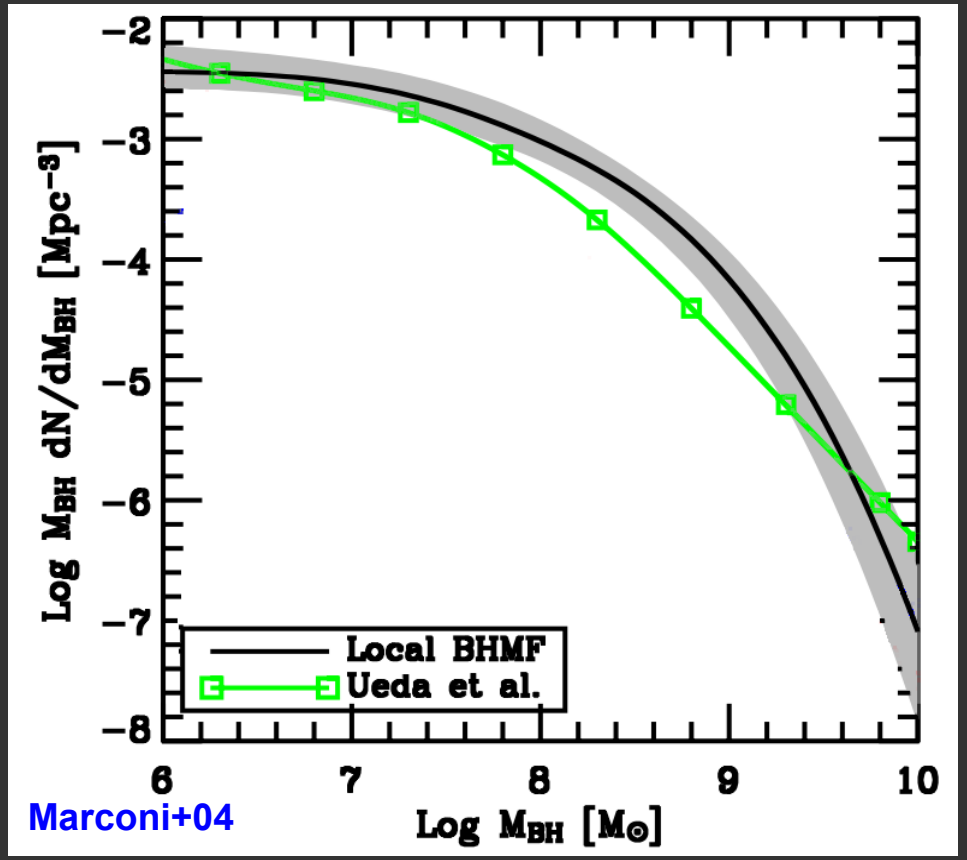

- Reflection fraction
- Γ
- $E_{Cut}$

Akylas+12

# Soltan argument

- Compute the **local SMBH mass function** (from $M_{BH}$-$\sigma$/$M_{BH}$-$L_{bulge}$ relation)

- Compare with mass function from **AGN relic** (observed LF) via continuity equation



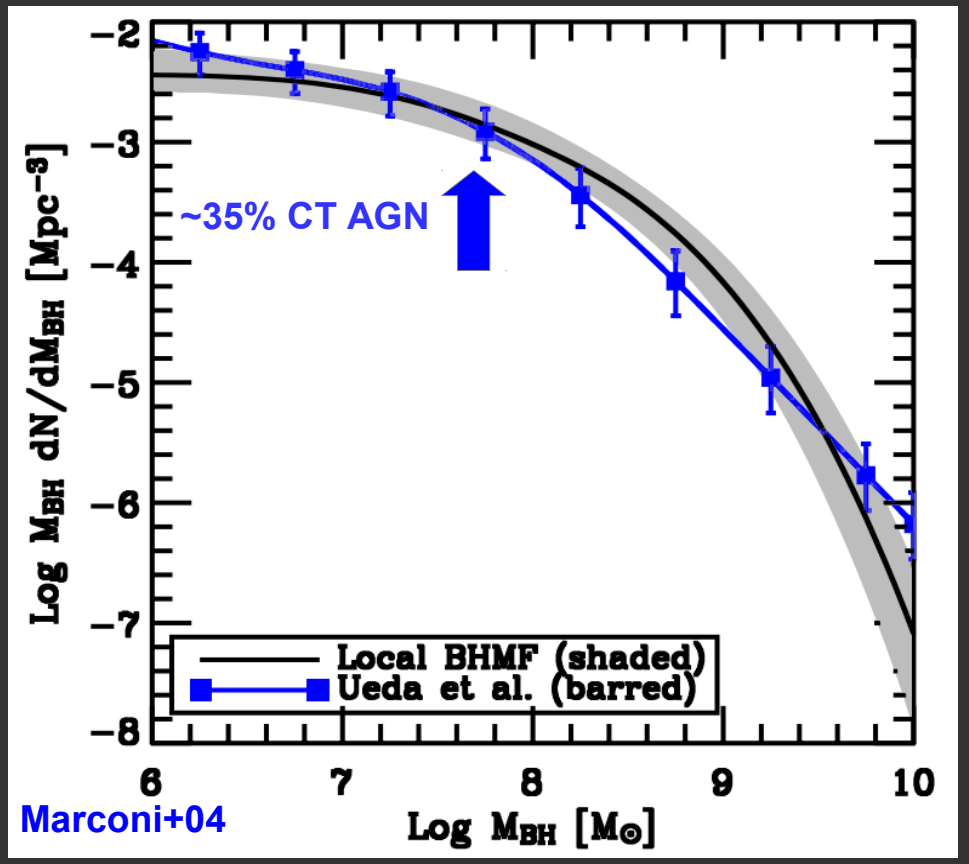
# Soltan argument

- Compute the **local SMBH mass function** (from $M_{BH}$-σ/$M_{BH}$-$L_{bulge}$ relation)

- Compare with mass function from **AGN relic** (observed LF) via continuity equation

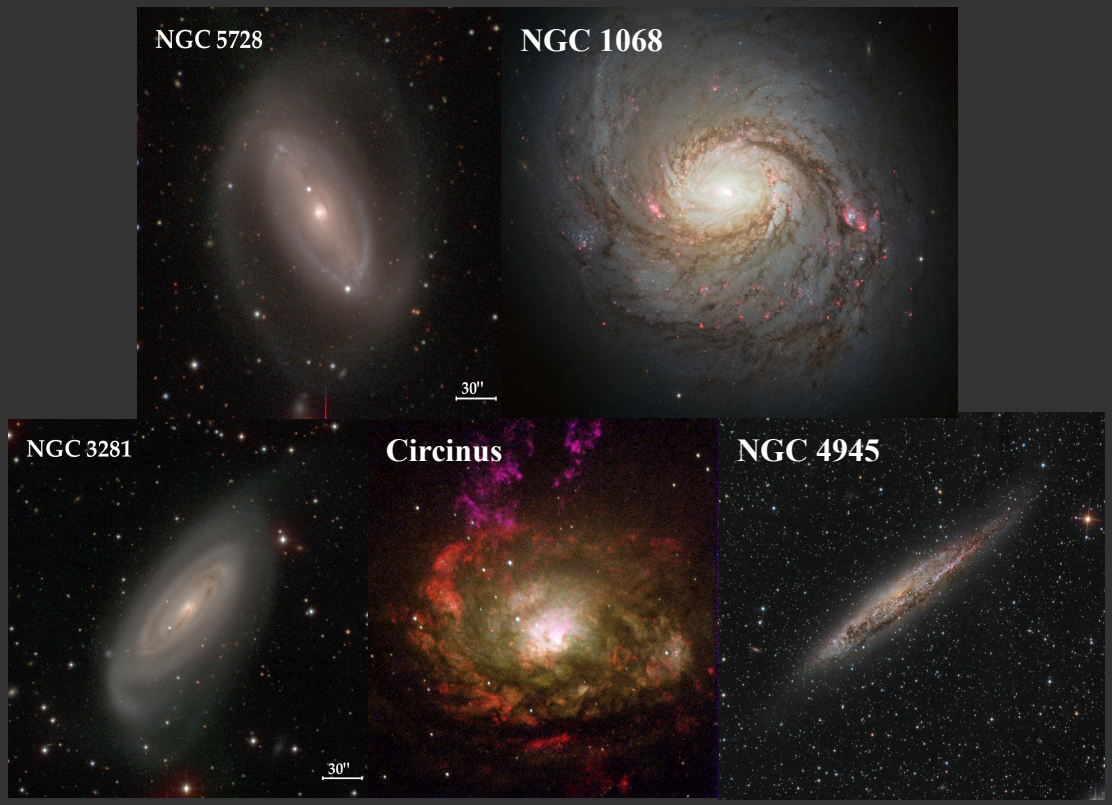
- Then add some % of CT AGN to match the two...

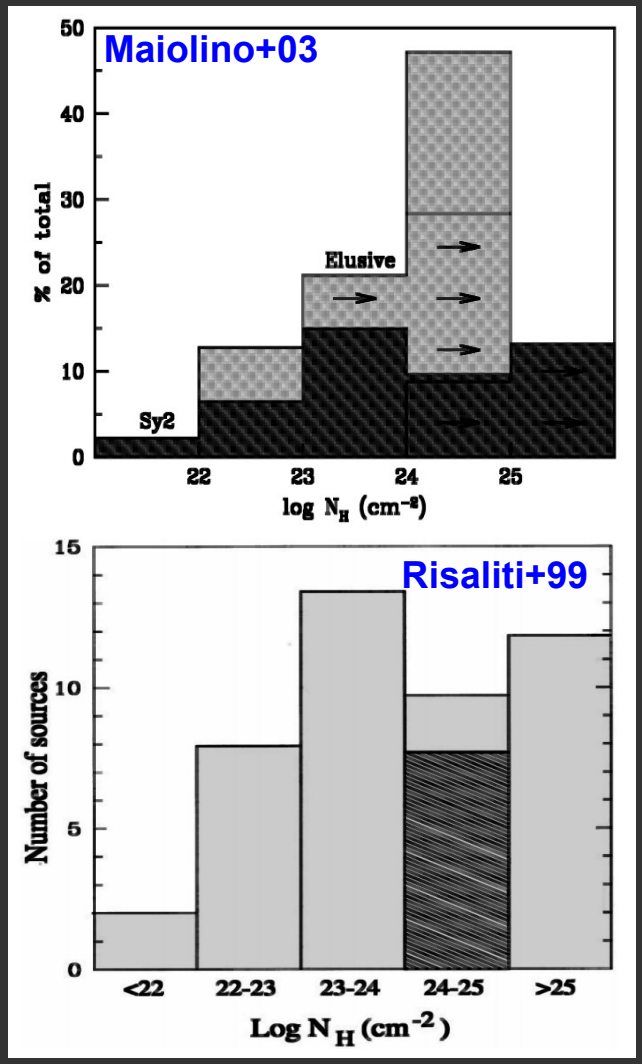
...assume $k_{Bol}$, ε, λ...



# CT AGN in the local Universe

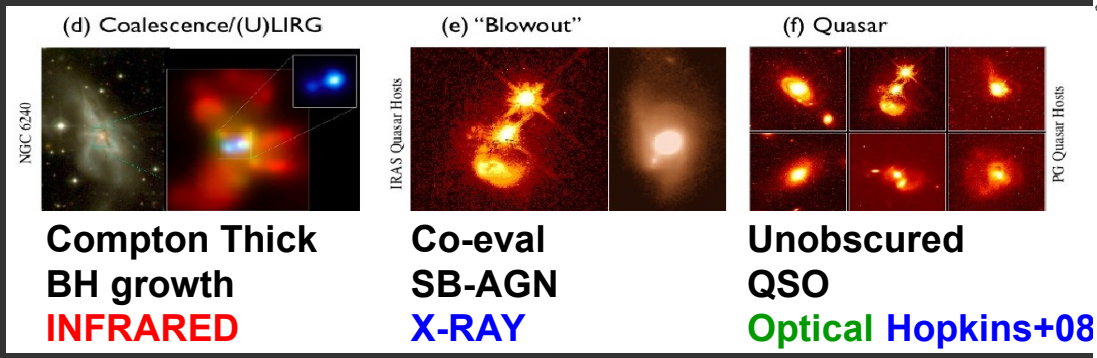
Common (>50% of Seyfert2)
in the local Universe (z < ~0.01)

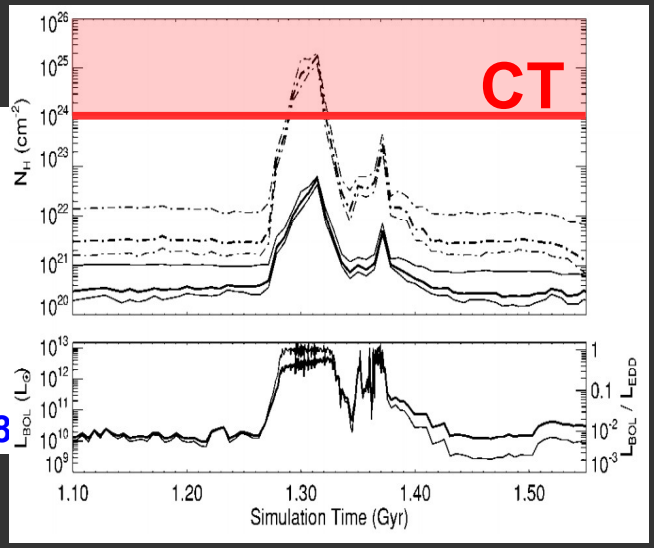


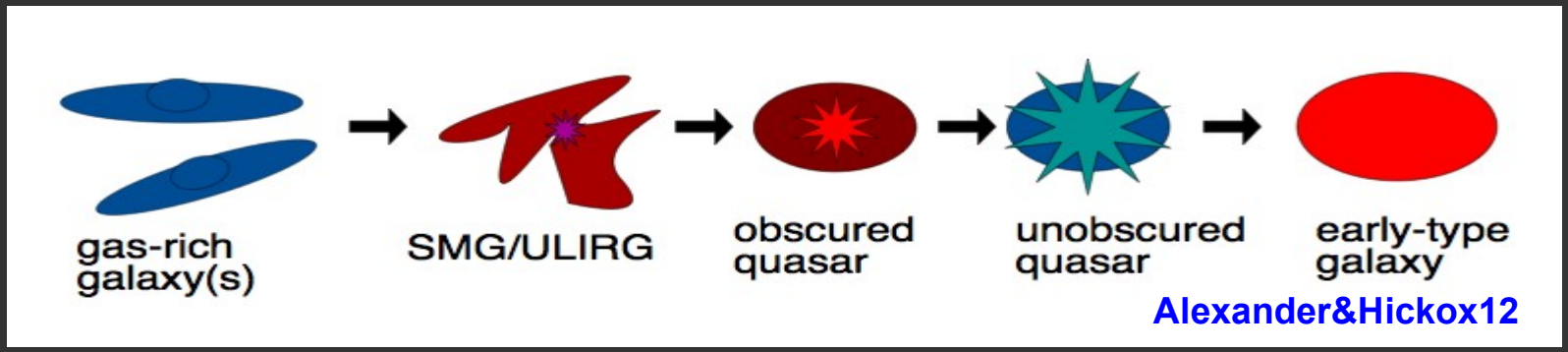

Nustar results in A. Marinucci's talk...
e.g. Puccetti+15, Marinucci+16, Guainazzi+16

# CT AGN and AGN/galaxy co-evolution




see Rodighiero and Bongiorno talks...




**Fast SMBH accretion and SF driven by gas-rich mergers is associated with CT AGN at high z**

Sanders+88; Di Matteo+05; Sazonov+05; Cattaneo+09, Debuhr+12, Banerji+12

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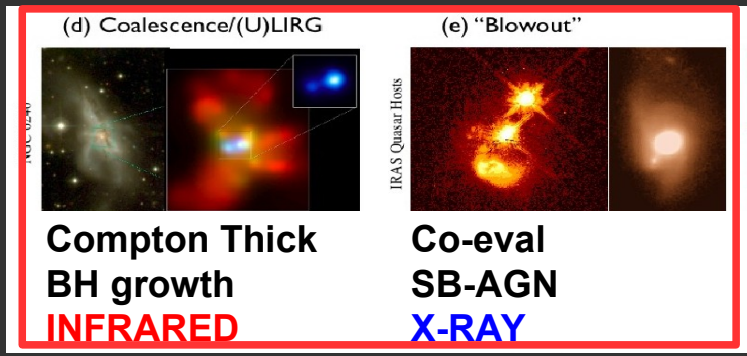


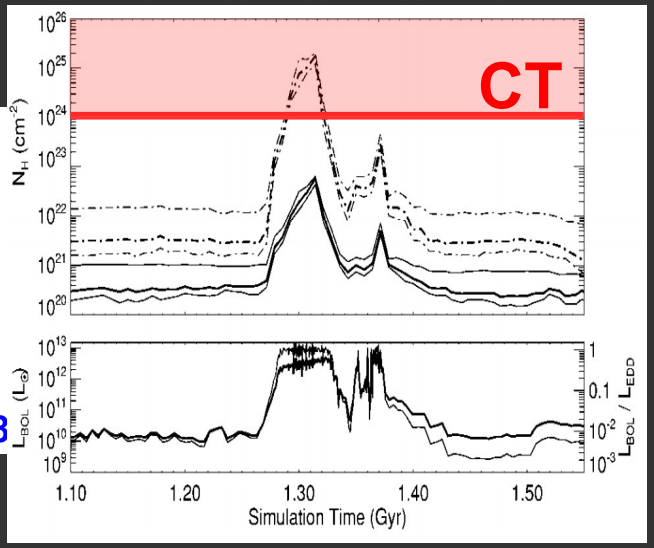


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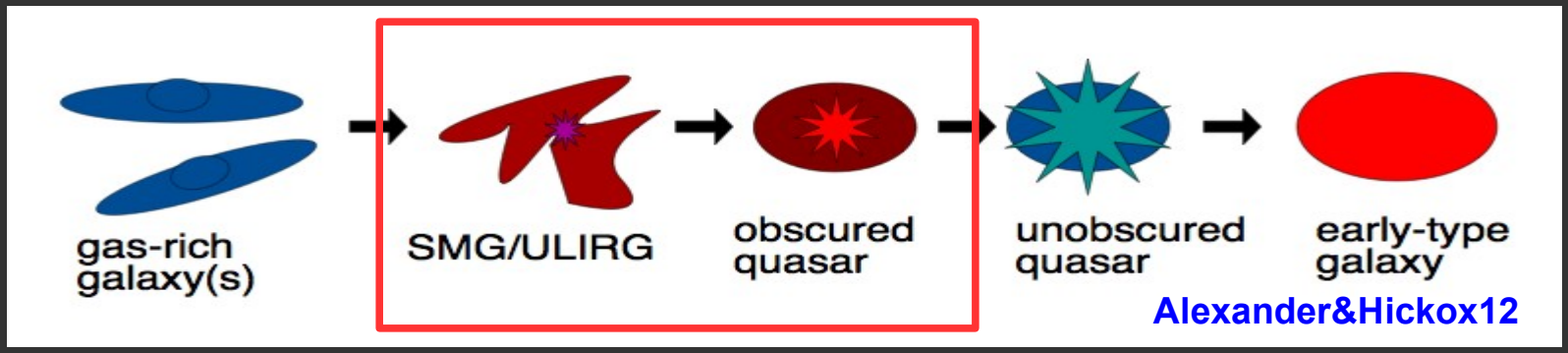


**Fast SMBH accretion and SF driven by gas-rich mergers is associated with CT AGN at high z**

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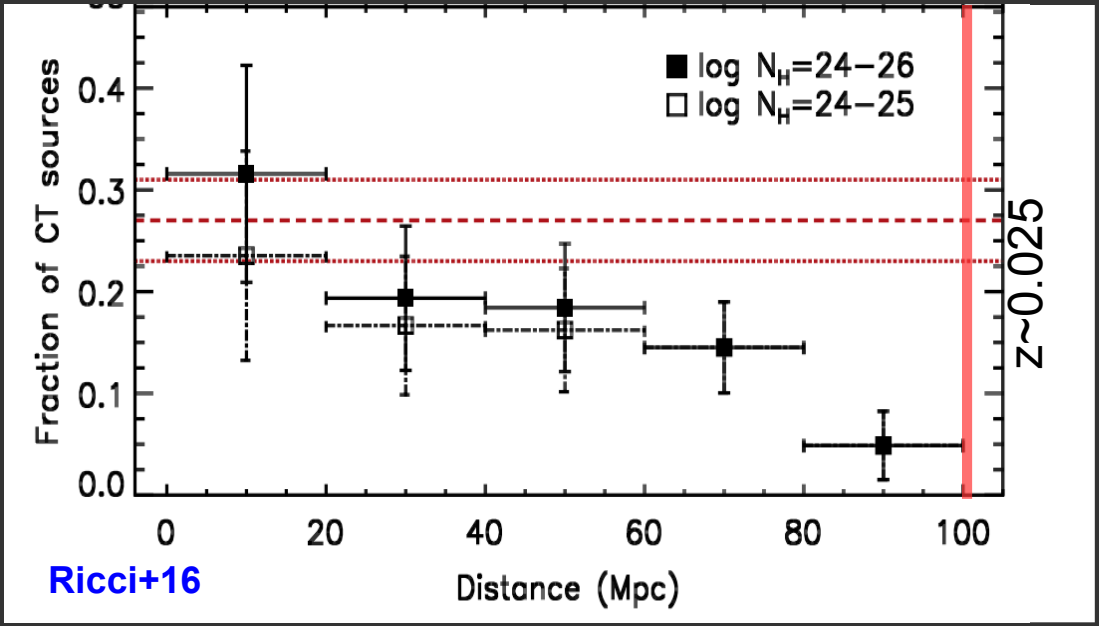
# CT beyond few Mpc...

**Difficult to detect in X-rays...**
**...even in 15-150 keV beyond ~100 Mpc!**

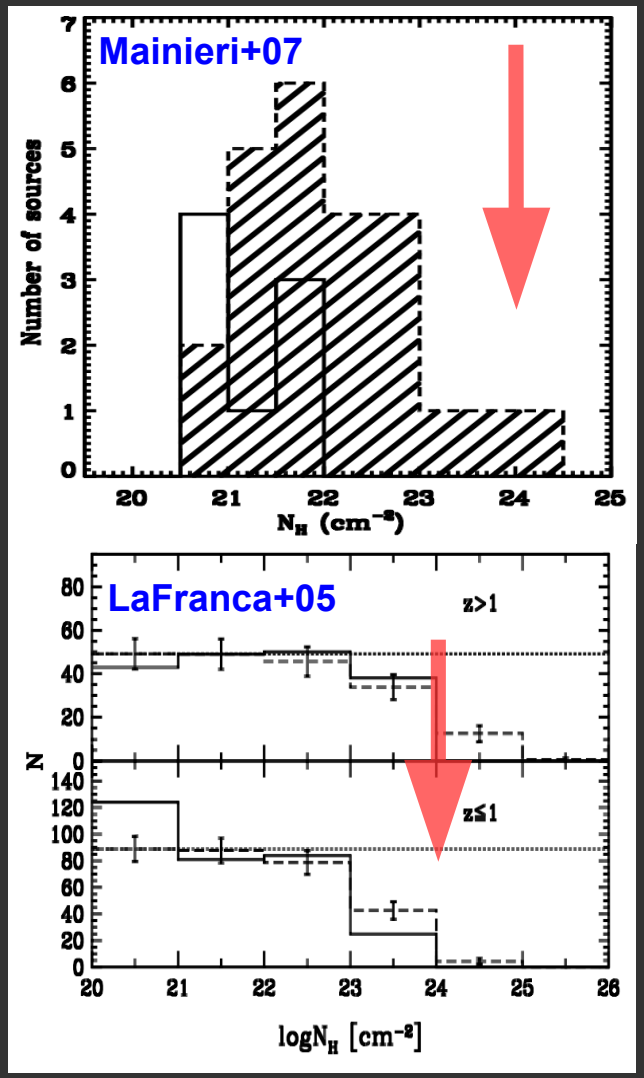


# ...and CT at high z

Few in shallow and medium surveys

GL+13, Marchesi+16

see Zappacosta's talk



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Few in shallow and medium surveys
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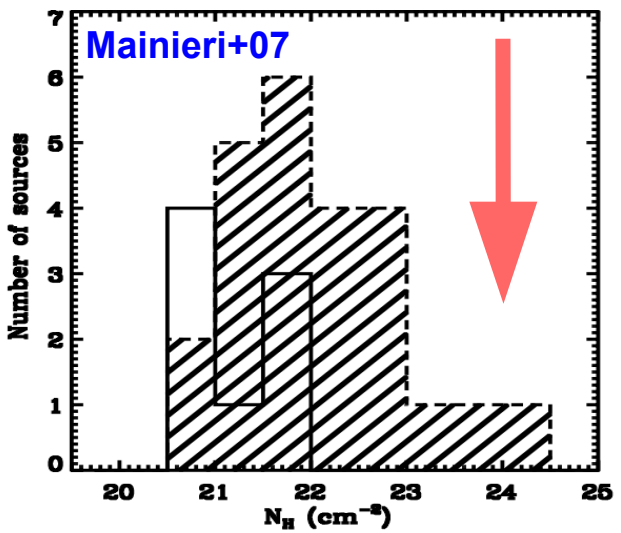
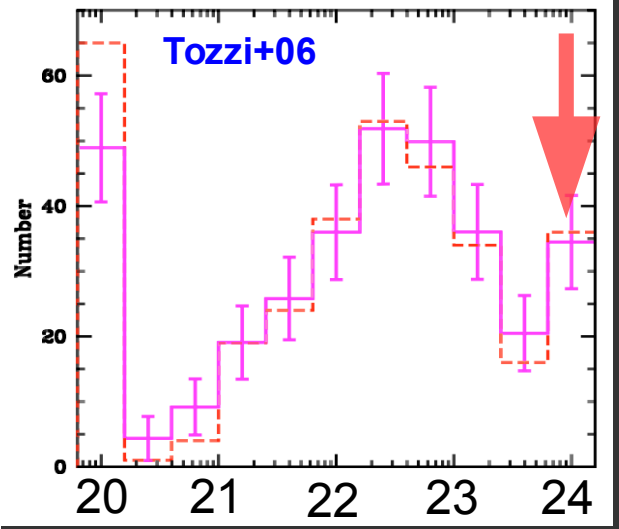
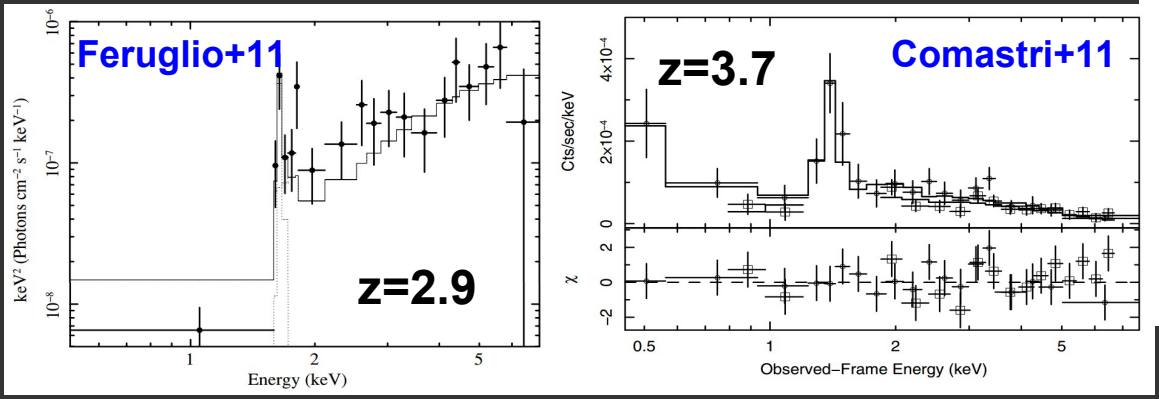
A few also in the CDFS
Iwasawa+12, Georgantopoulos+13



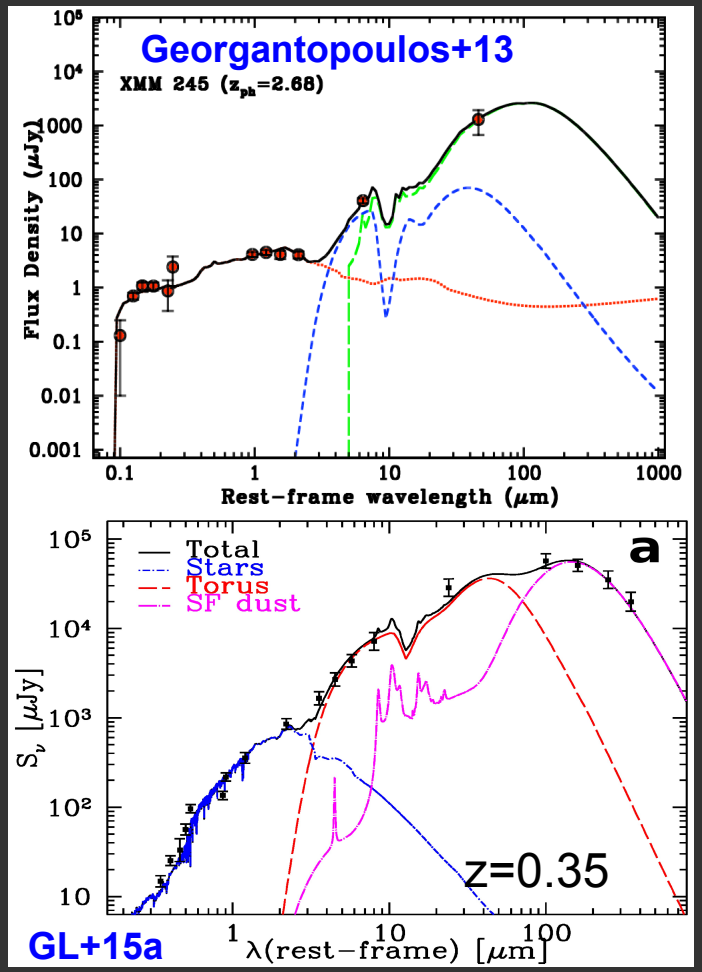



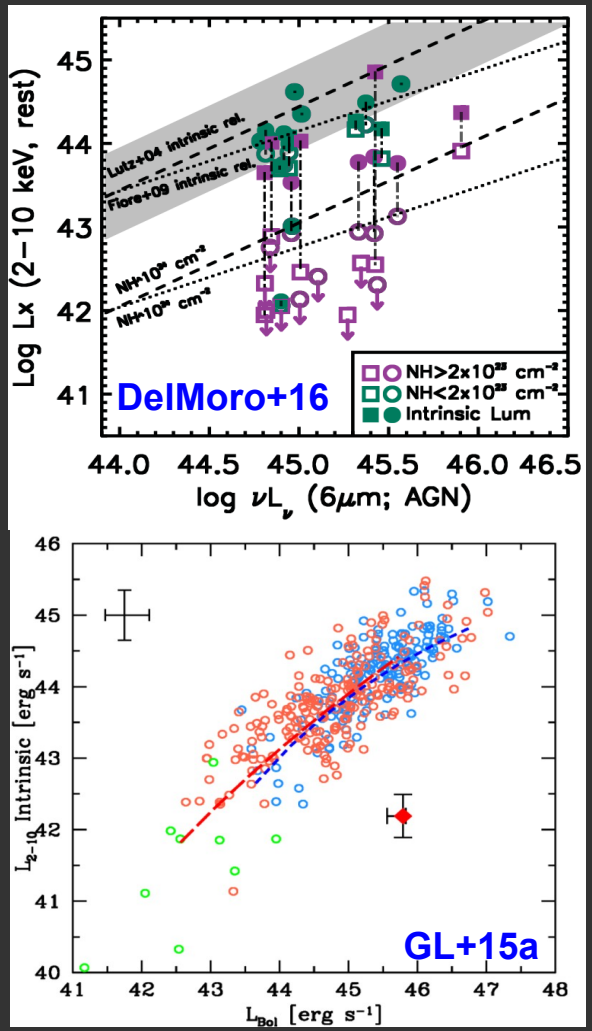



# Multi-λ selection of CT AGN

## Based on SED properties prominent torus

Daddi+07, Fiore+08,09, Alexander+08,13, Stern+14, Lansbury+15 etc...



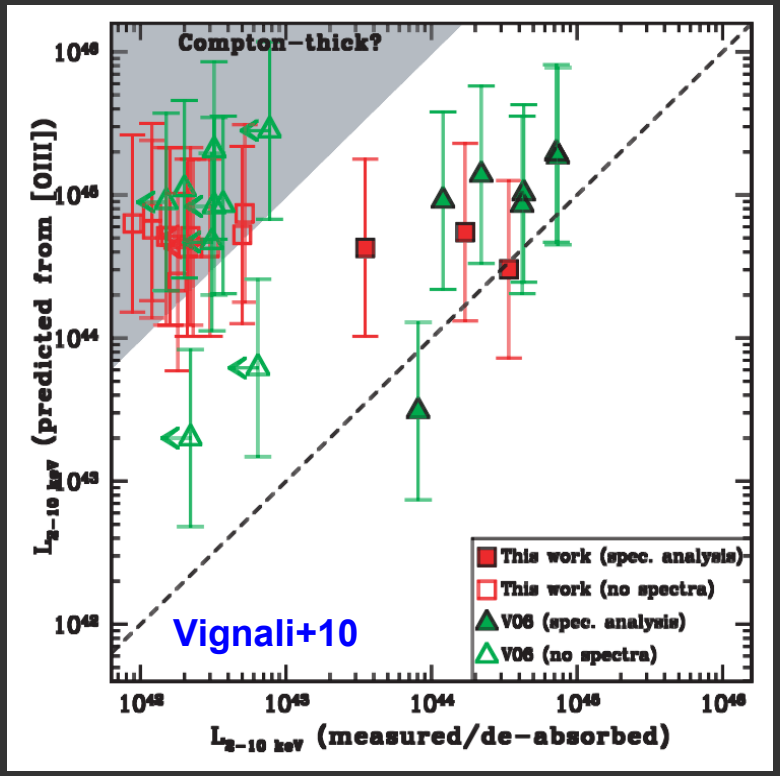



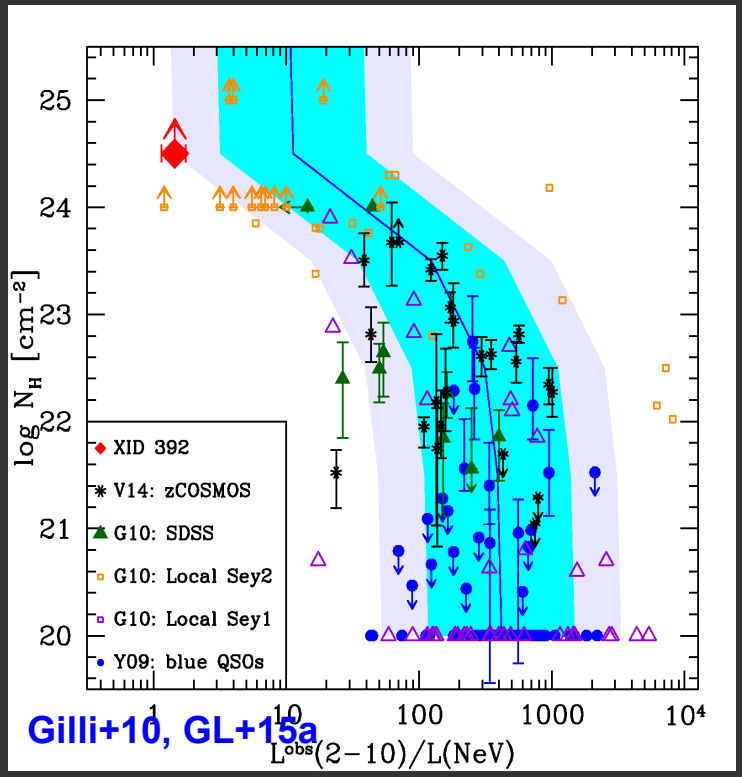

see A. Zaino's talk...

# Multi-λ selection of CT AGN

## $L_{AGN}$ from NLR emission lines and suppression of the X-ray flux

Panessa+06, Vignali+06, Mignoli+13

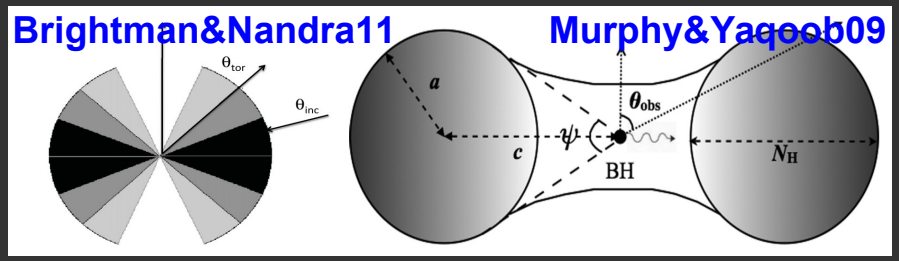



see M. Mignoli's talk..

# New results from X-ray spectra

**New models:** Toroidal geometry, MC simulations of radiative transfer



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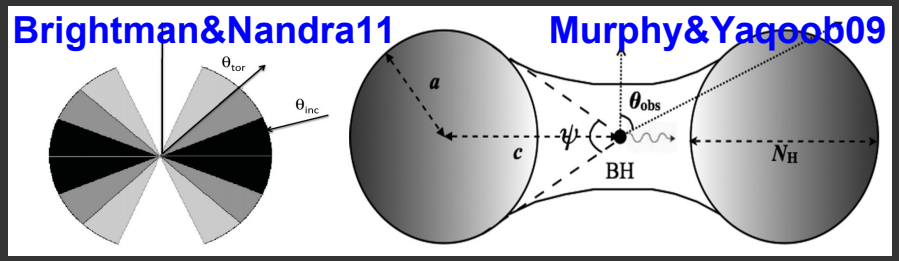
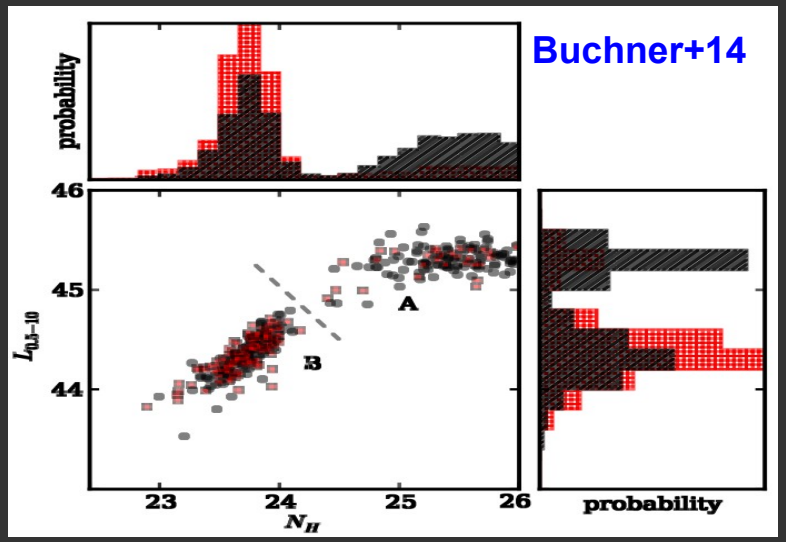



**New techniques:** unbinned fits, bkg modeling, MCMC, Bayesian stats

Fiore+12, Akylas+16



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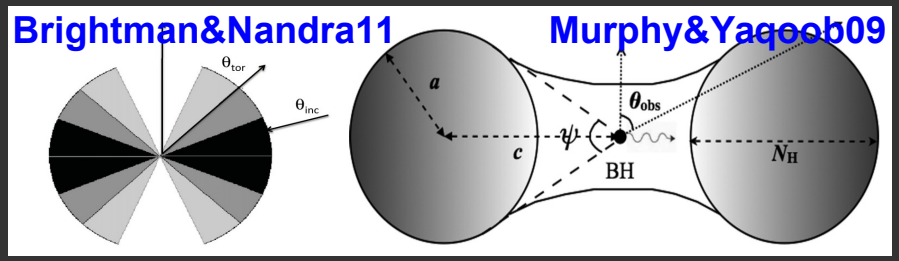


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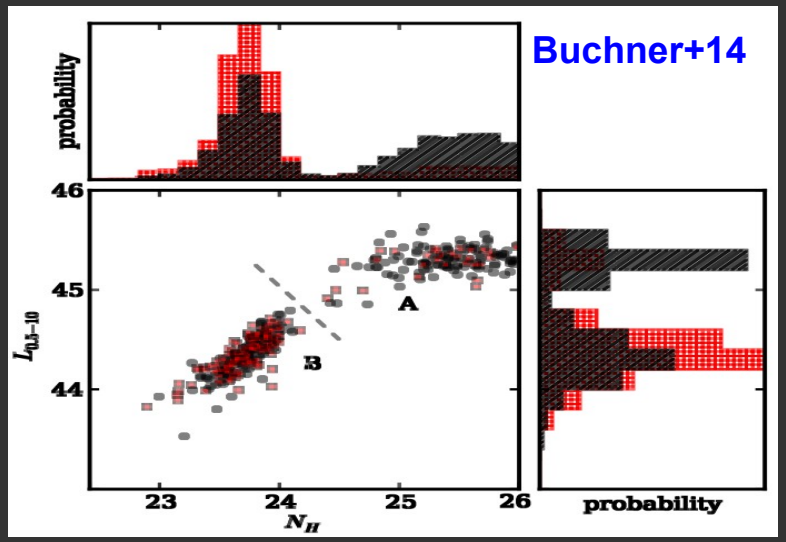
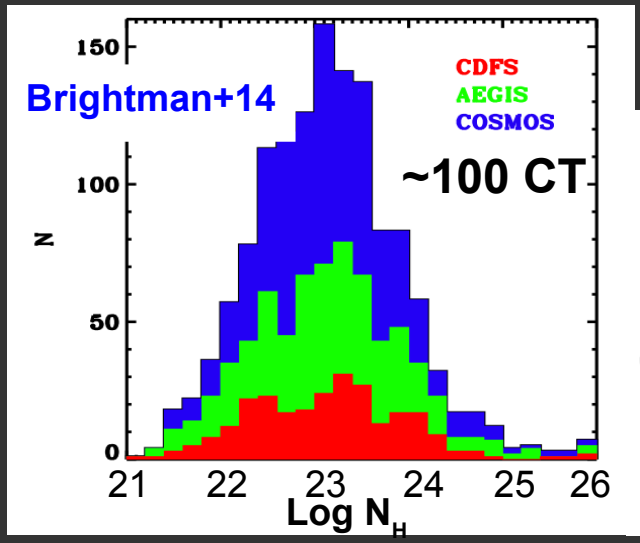
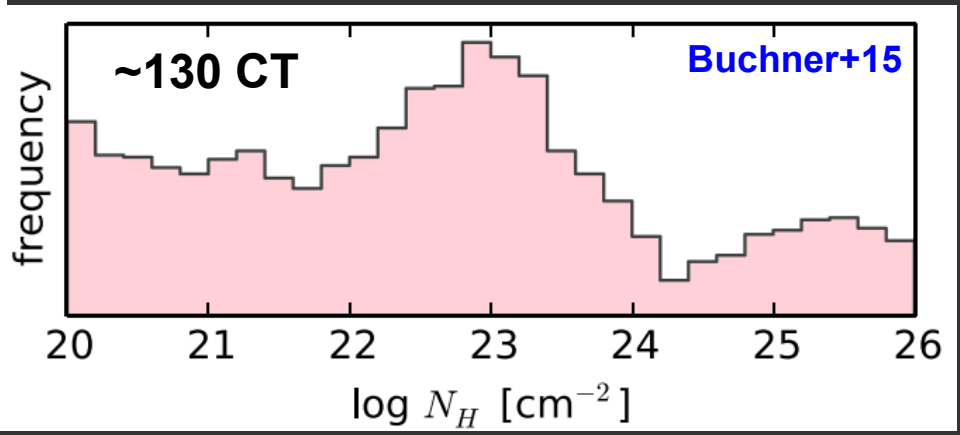


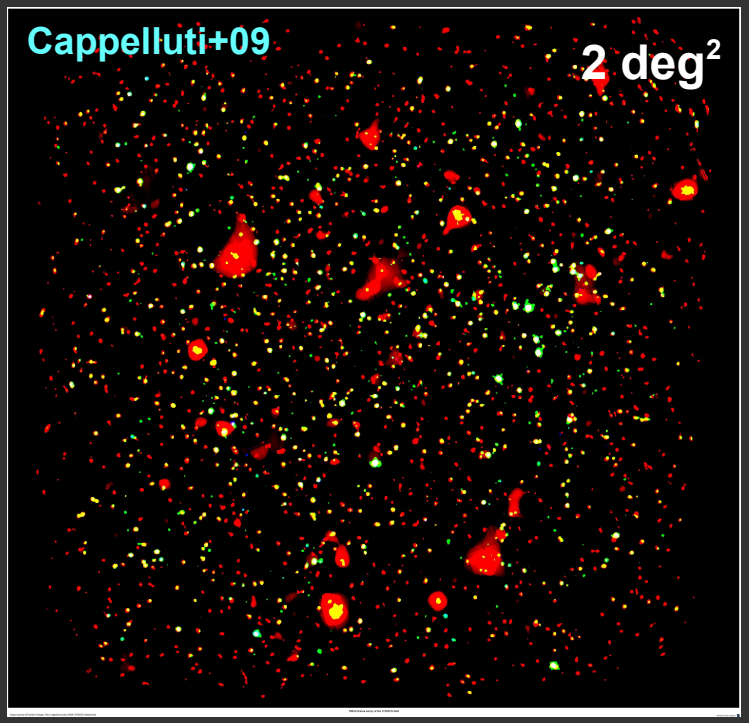



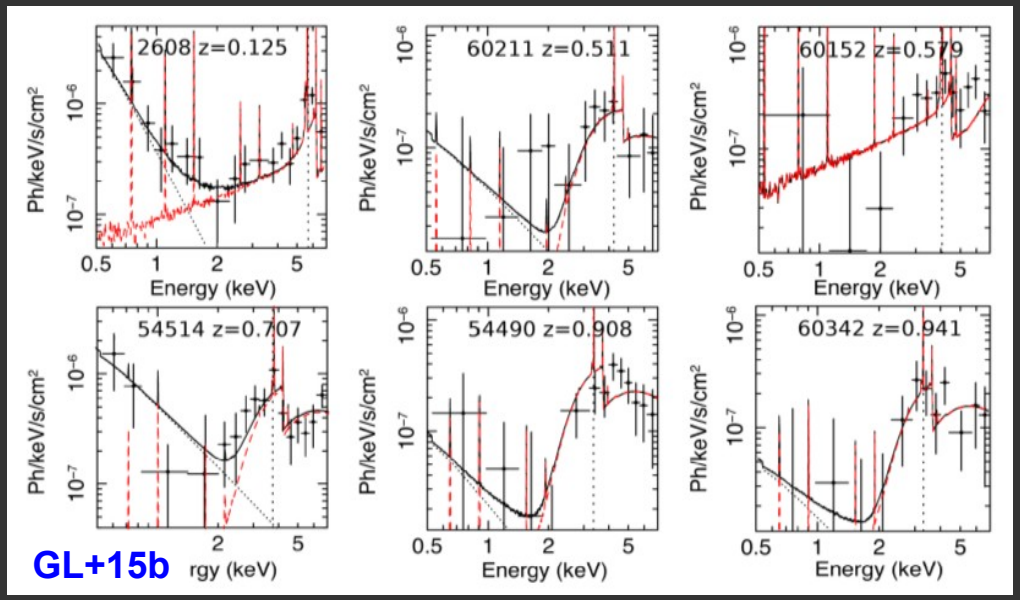
# CT selection in COSMOS (1)

1) using the XMM catalog:
**~1200 AGN** with >30 counts

- Testing BNTorus and MYtorus

- Deeper Chandra data to test the selection




**10 CT candidates**
29 highly obscured but C-thin
80% efficiency of the selection

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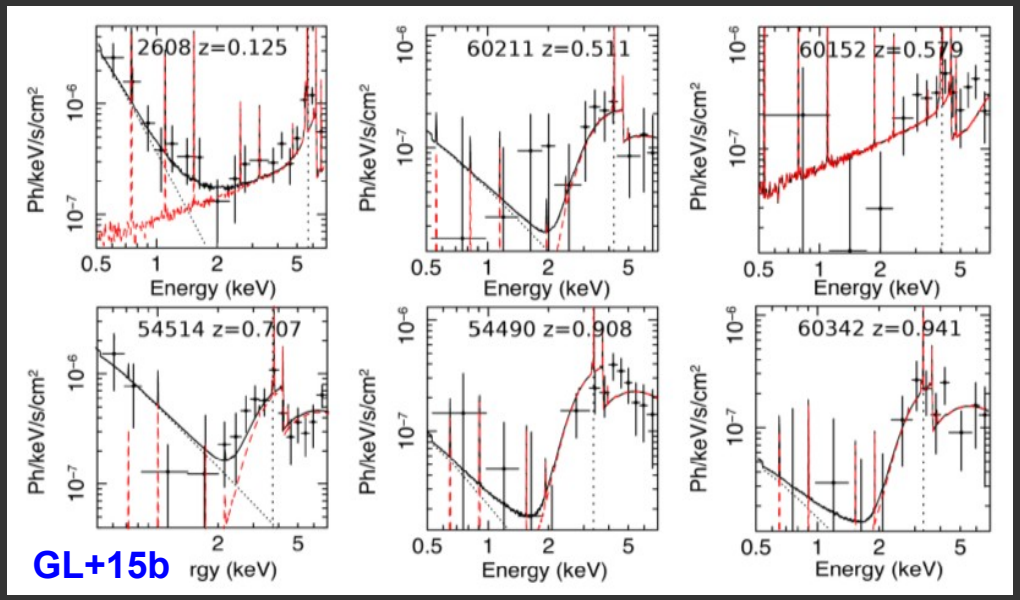
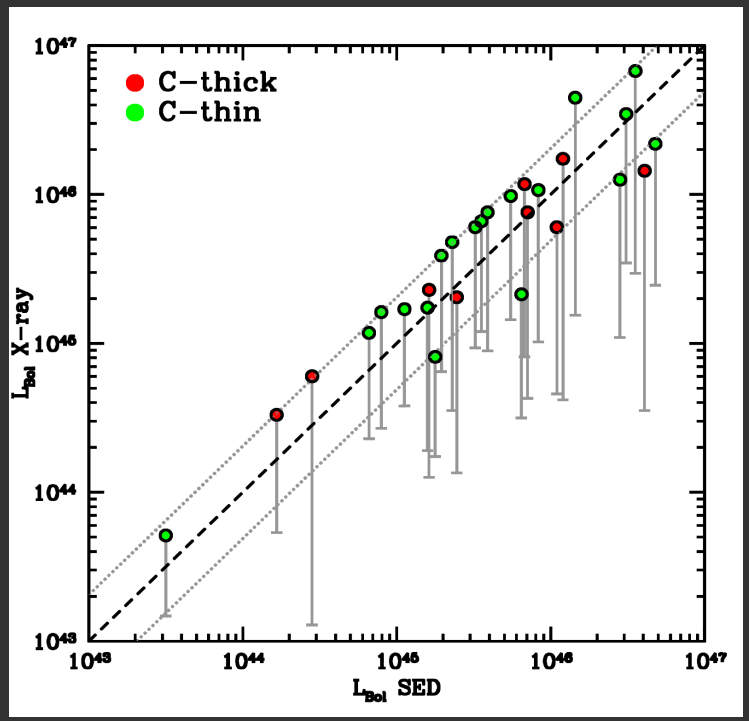
- Check $L_{Bol}$ from SED

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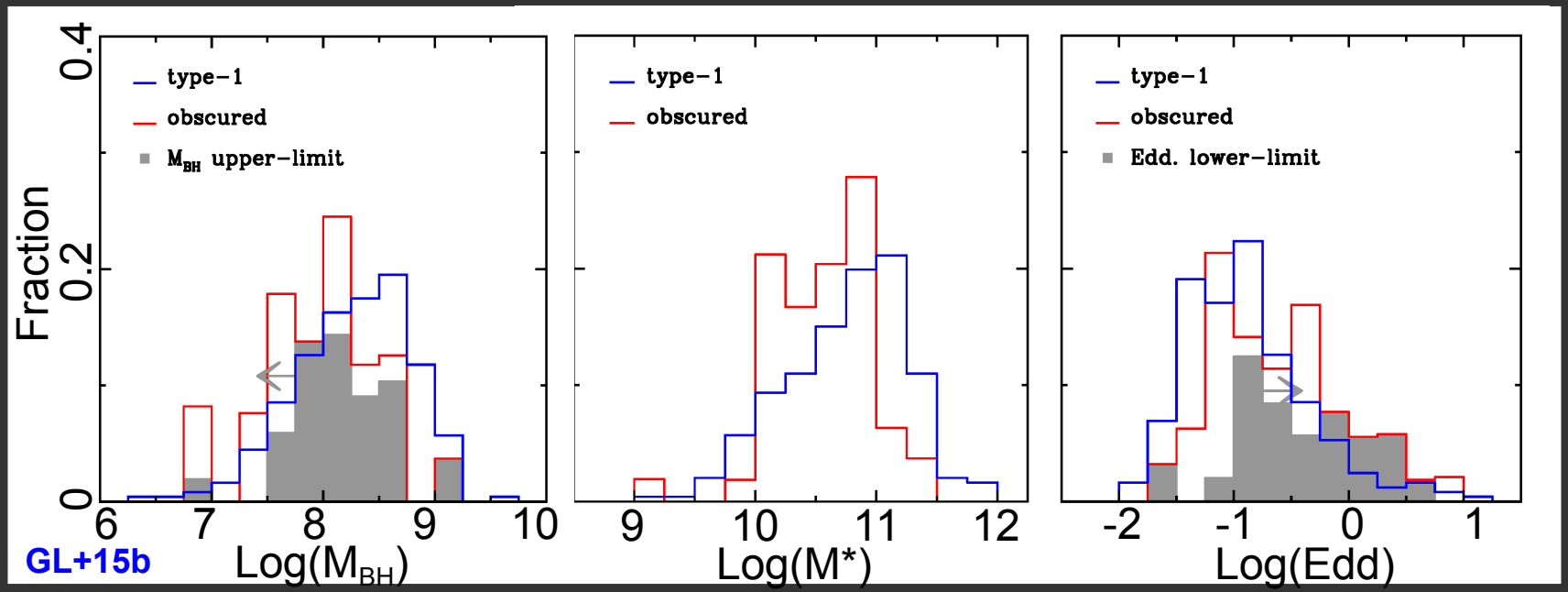
# Host properties

**Lower $M_{BH}$ and M* and higher Edd. ratio**
**(at >2.5σ)**
**w.r.t. Type-1 AGN matched in $L_X$ and z**

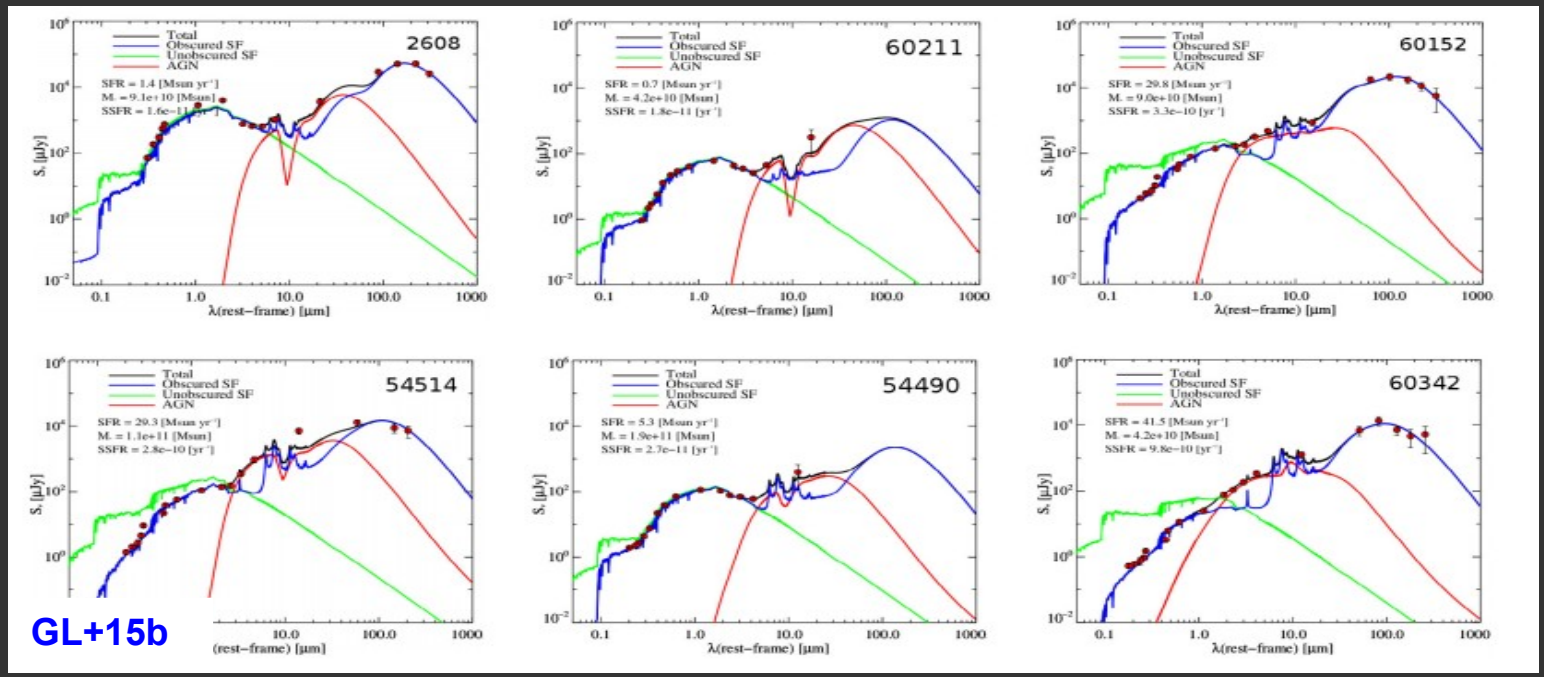



**but see F. La Franca's talk...**

# Host properties

**SFR = few – 300 $M_{Sun}$**
**sSFR ~ MS at all z**
**No Starbursts (>4xMS)**

Credit: I. Delvecchio, S. Berta



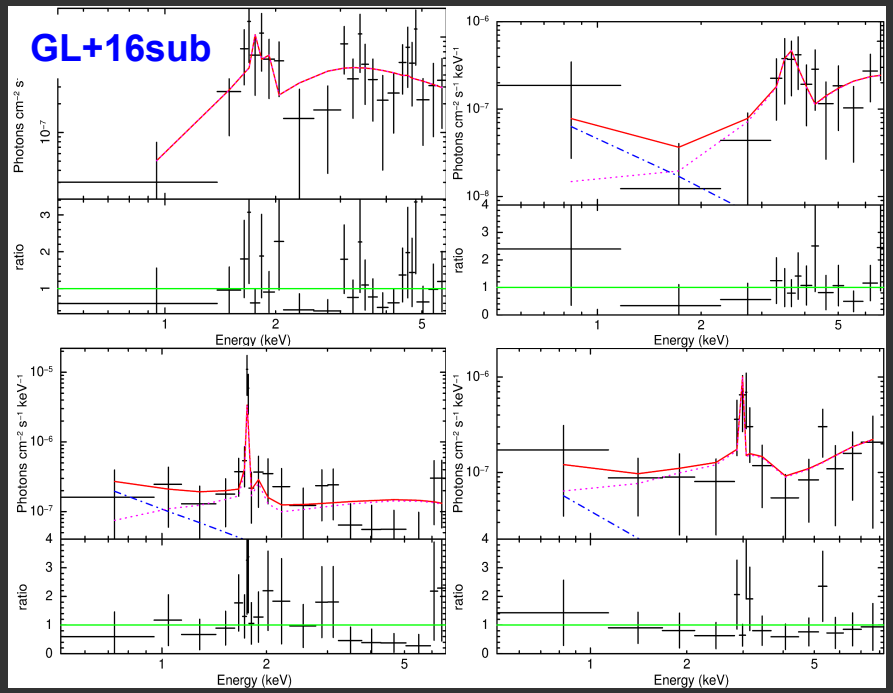

GL+15b

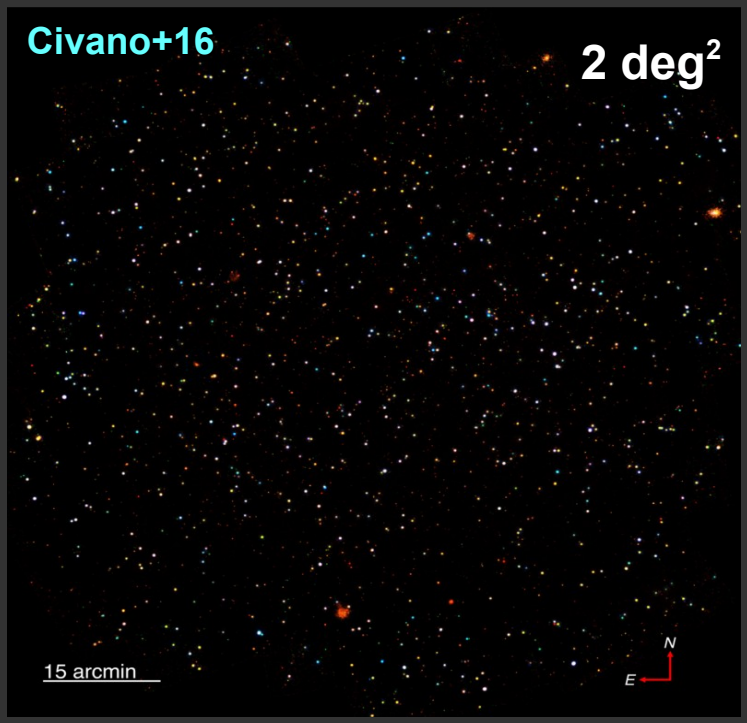
# CT selection in COSMOS (2)

2) using the C-Legacy catalog:
**~2000 AGN** with >30 counts

- BNTorus

- Using the full $N_H$ PDF




**64 CT candidates**
**34 summing up the PDFs**

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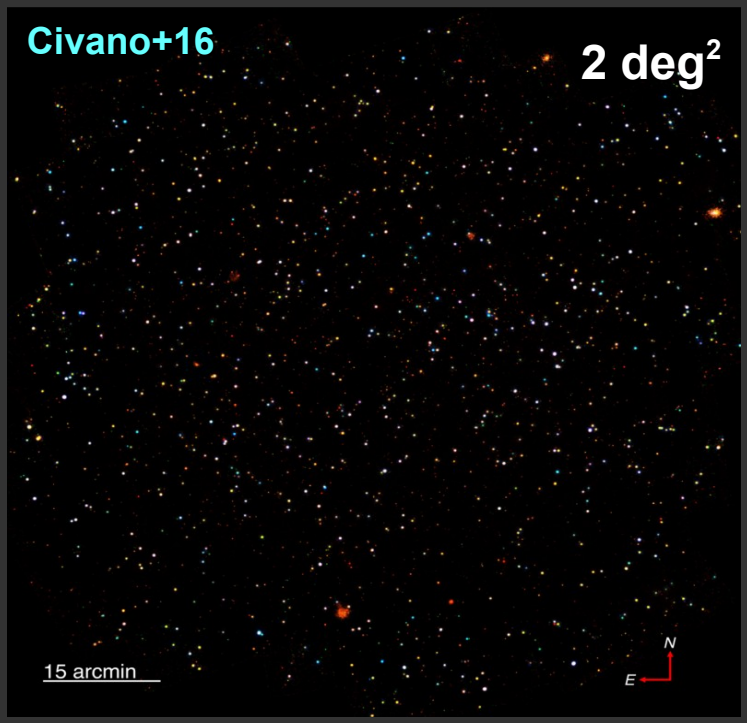
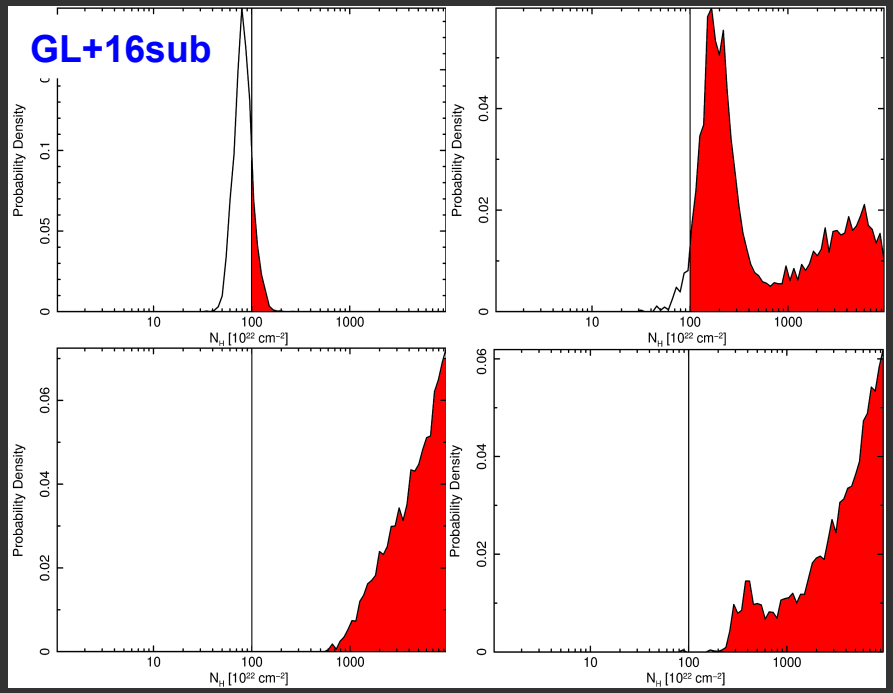
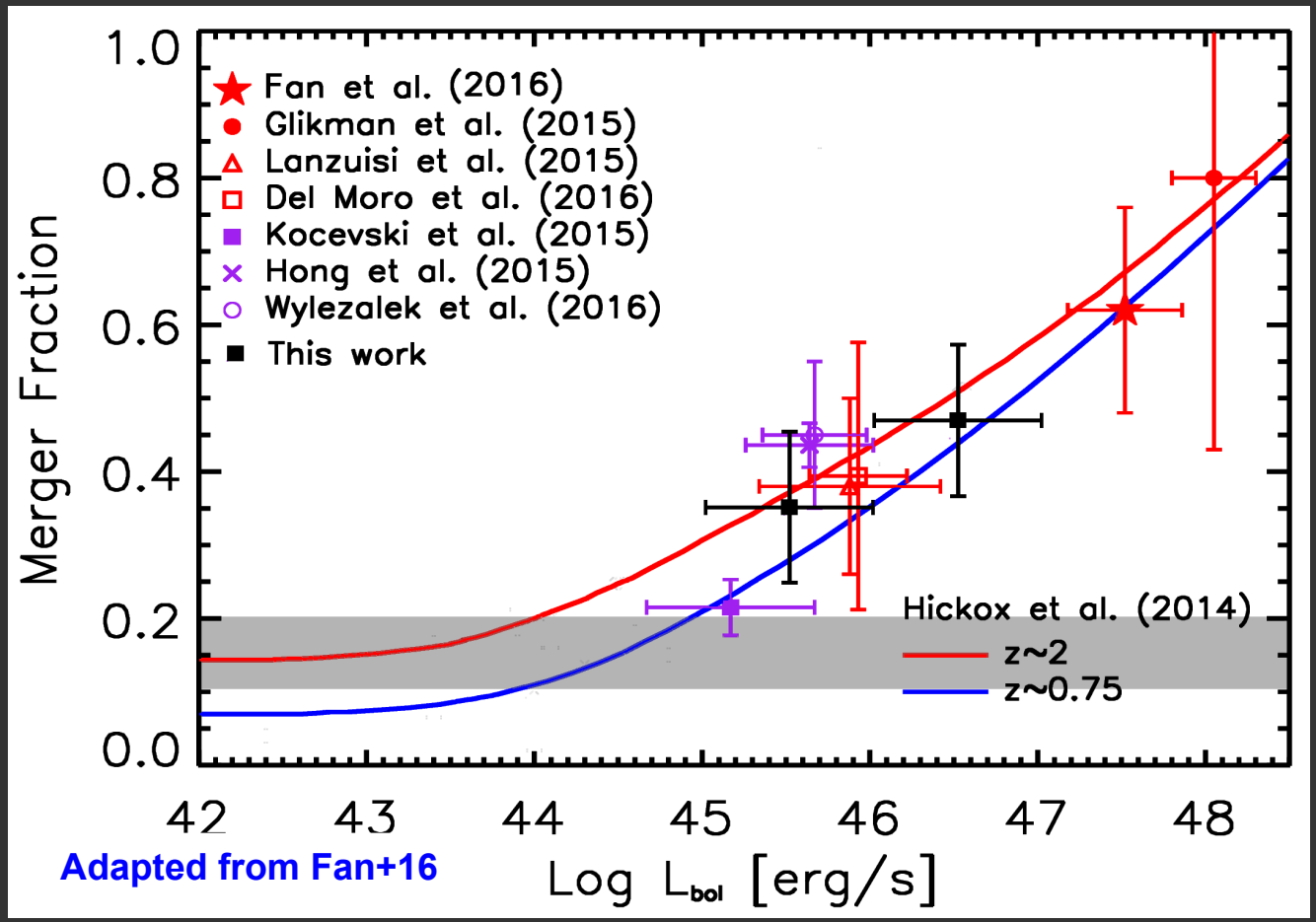



**64 CT candidates**
34 summing up the PDFs

# Host properties

**35-45% of merging/disturbed systems**
**(wrt ~10-20% for X-ray selected AGN)**
Kocevski+15, Del Moro+16




# Comparison with XRB models

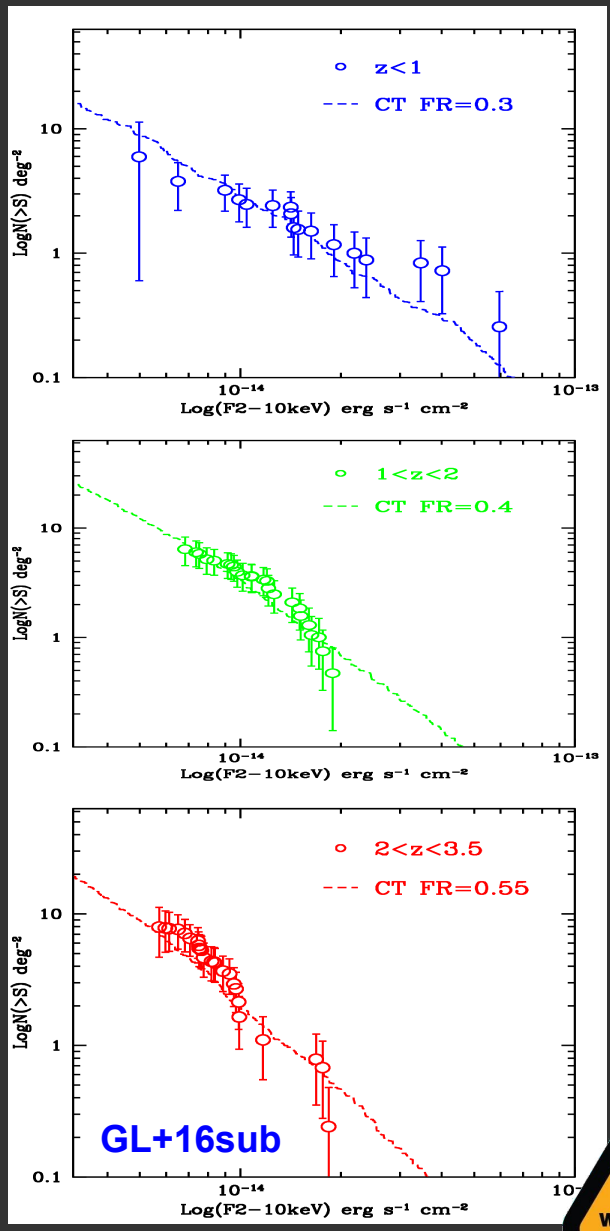
- Number counts consistent with **XRB models** at z<1 Akylas+12

- Increase of the CT fraction at high z
Not consistent with other models?

Caveat:

- highly uncertain distribution at $N_H > 10^{25}$ cm$^{-2}$ see Comastri+15

- highly uncertain **refl. fraction**




# Conclusions

- Using new approaches Chandra and XMM can identify large samples of CT AGN at z~1-3

- Multi-λ coverage is needed to verify the identification

- Multi-λ is usefull to derive host and SMBH properties to test evolutionary models

- Full characterization at high z:
  few bright high z CT AGN (from large area surveys XXL, S82, WISE)
  deep XMM follow-up allows to put constraints on refl. fraction,
  torus opening angle, system inclination etc....
  e.g. Piconcelli+15