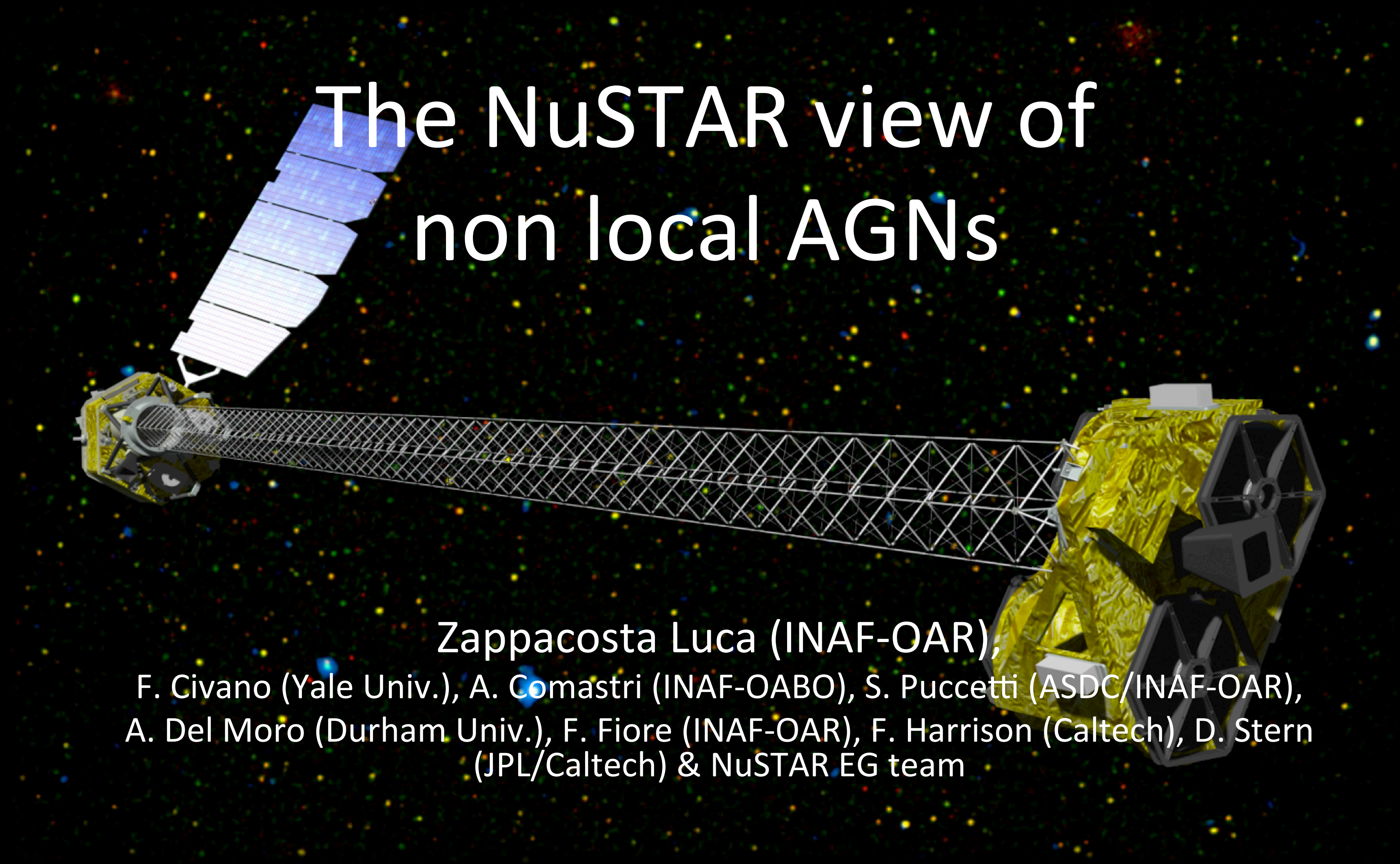
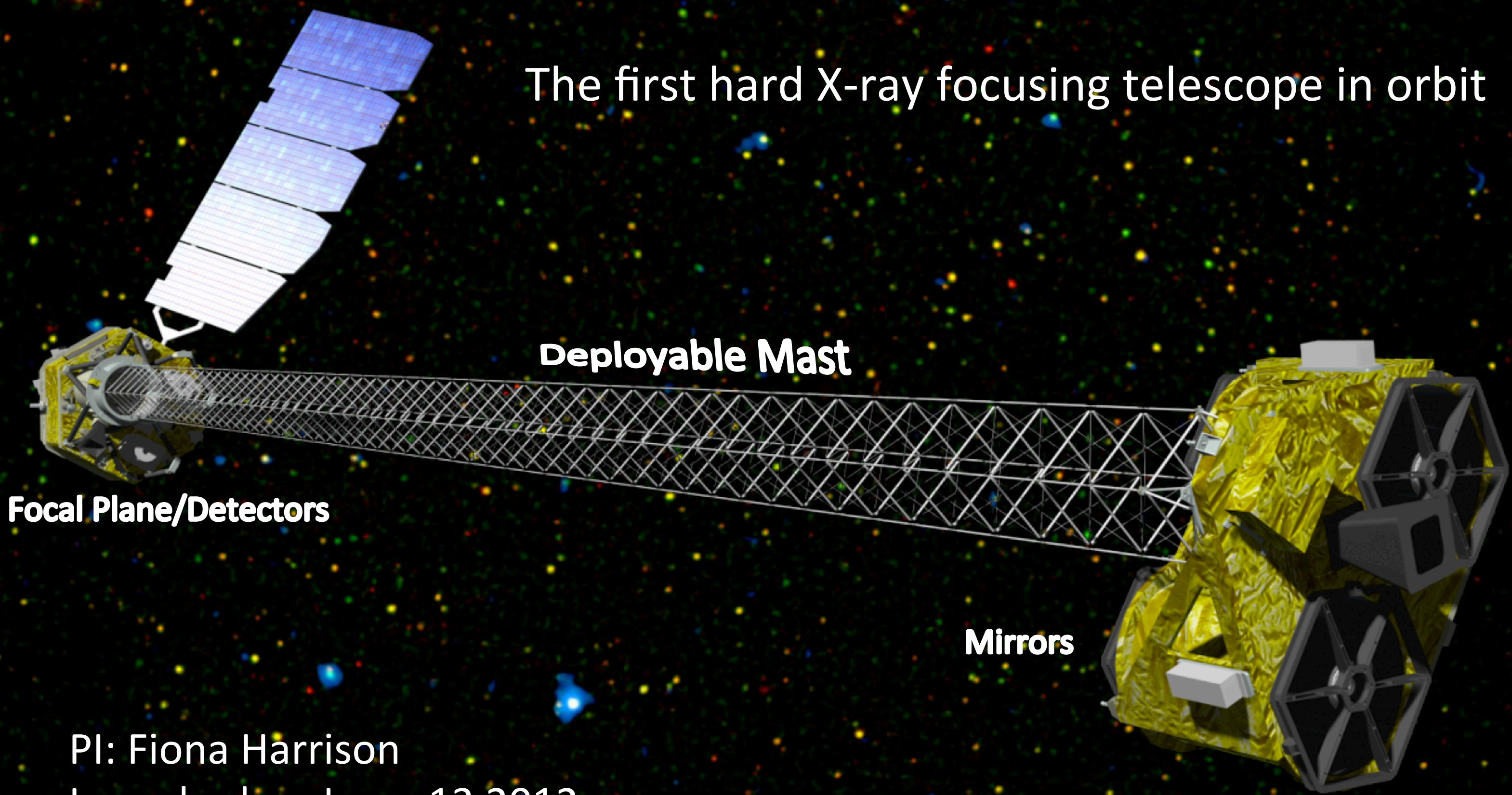
The NuSTAR view of non local AGNs



Zappacosta Luca (INAF-OAR),
F. Civano (Yale Univ.), A. Comastri (INAF-OABO), S. Puccetti (ASDC/INAF-OAR), A. Del Moro (Durham Univ.), F. Fiore (INAF-OAR), F. Harrison (Caltech), D. Stern (JPL/Caltech) & NuSTAR EG team

Nuclear Spectroscopic Telescope Array

The first hard X-ray focusing telescope in orbit

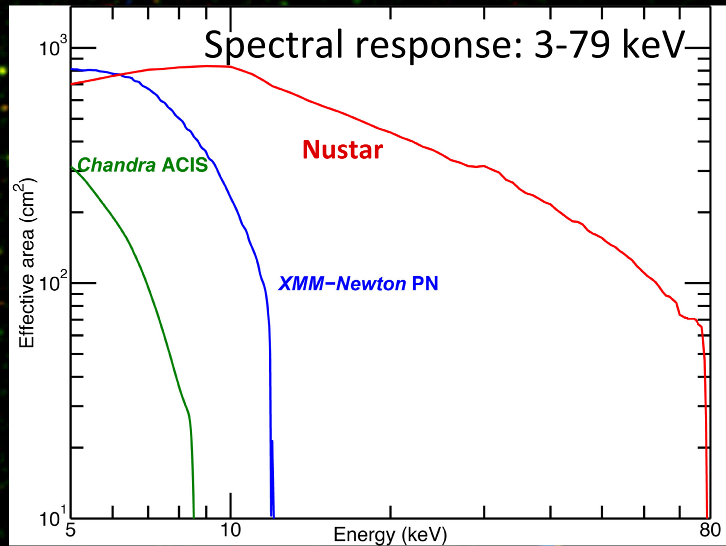


PI: Fiona Harrison
Launched on June, 13 2012

NASA senior review 2014: extension approved for 2+2 years

NuSTAR characteristics

- Focuses X-rays up to 79 keV
  - FoV: 12.5′ x 12.5′
  - FWHM: 18″
  - HPD: 58″
  - Localization: 2.5″ (1σ)



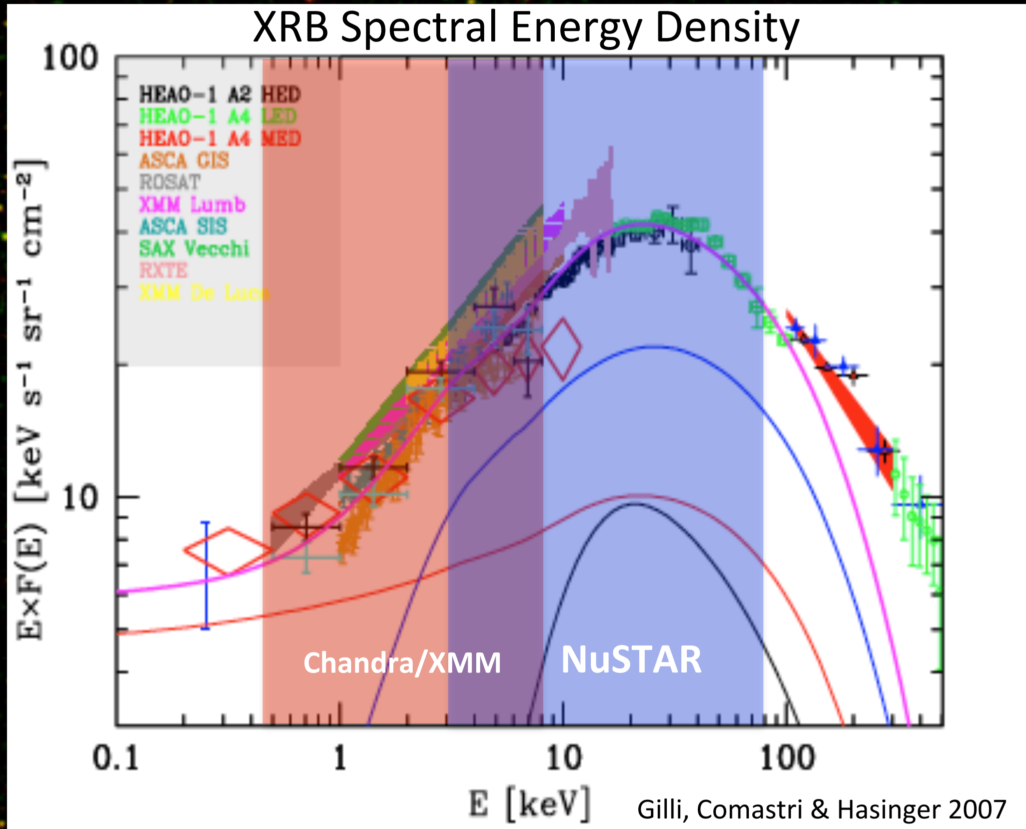
Improvements wrt previous hard X-ray instruments (Swift-BAT, Integral)

- Better spatial resolution (sub-arcmin)
- Better sensitivity (> 100x)

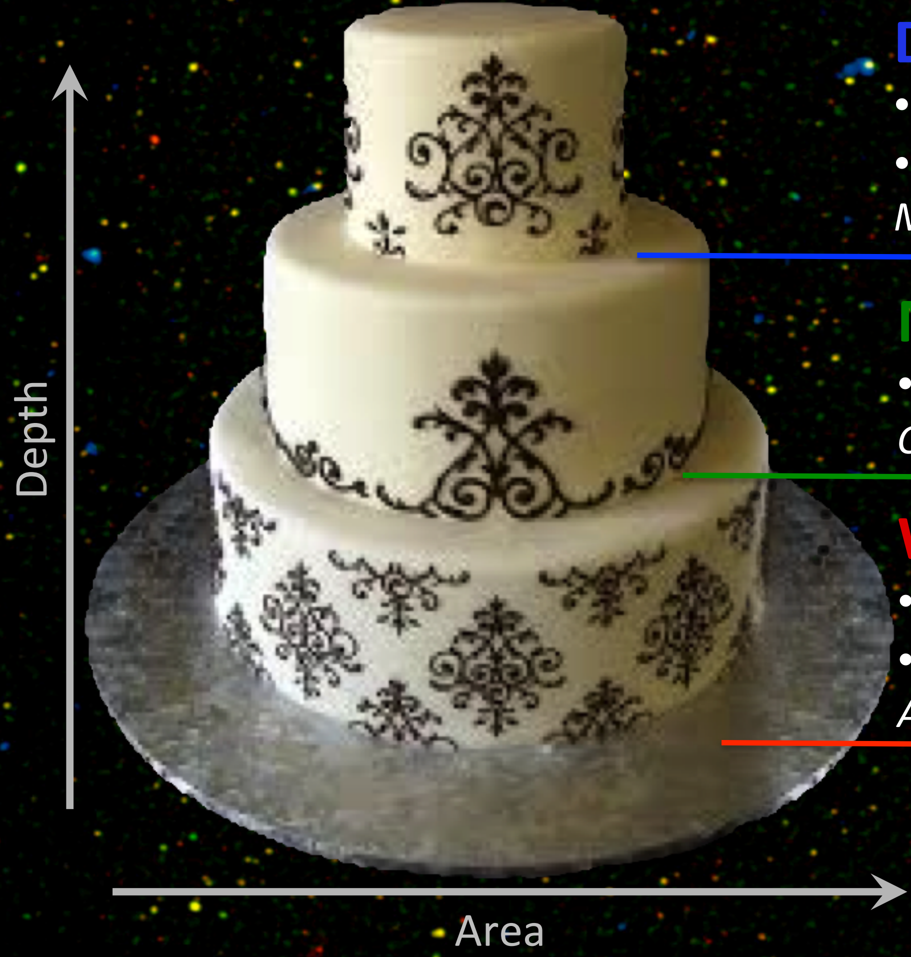
Allows to resolve a consistent fraction of the X-ray Background (XRB) @ > 10 keV

X-ray Background with NuSTAR

- Insights on the composition of the XRB peak at 20-30 keV by resolving 30-50% of the sources through direct detection and stacking
- NuSTAR almost not biased by obscured sources
  → Evolution of the active phase and obscuration with redshift



Multi-tiered approach: the Wedding Cake



Deep/narrow:

- E-CDF-S: ~200 ks/pointing over 0.3 deg^2
- EGS: ~200 ks/pointing over 0.18 deg^2

Mullaney et al. in prep., Aird et al. in prep.

Medium:

- COSMOS: ~25 ks/pointing over ~2 deg^2

Civano et al. in prep

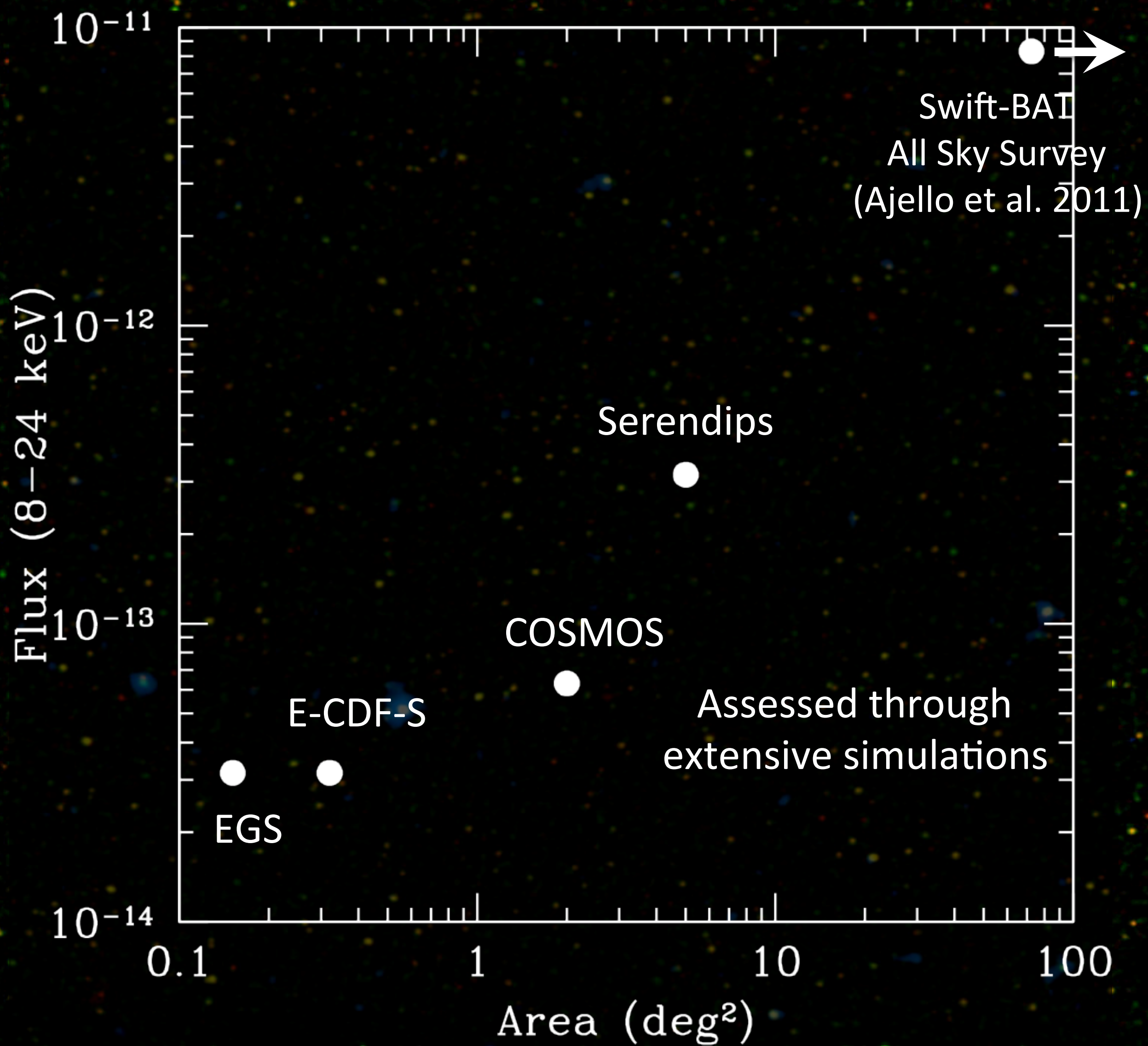
Wide/Shallow:

- 100 Swift-BAT AGN fields
- All NuSTAR targeted fields

} ~4-5 deg^2

Alexander et al. 2013, Landsbury et al. in prep.

NuSTAR Survey Sensitivity



Spectral analysis

Zappacosta et al. in prep.

- Sample selection
  - COSMOS+ECDF-S (2 deg^2)
  - Flux limited sample → F (8-24 keV) >= 7 10^{-14} erg s^{-1} cm^{-2}
  - 35 objects (31 from COSMOS + 4 from ECDF-S)
  - COSMOS objects analyzed so far – ECDF-S analysis is on-going

- Nustar only modeling: 3-24 keV

- Joint broad-band Nustar+Chandra+XMM modeling: 0.5-24 keV

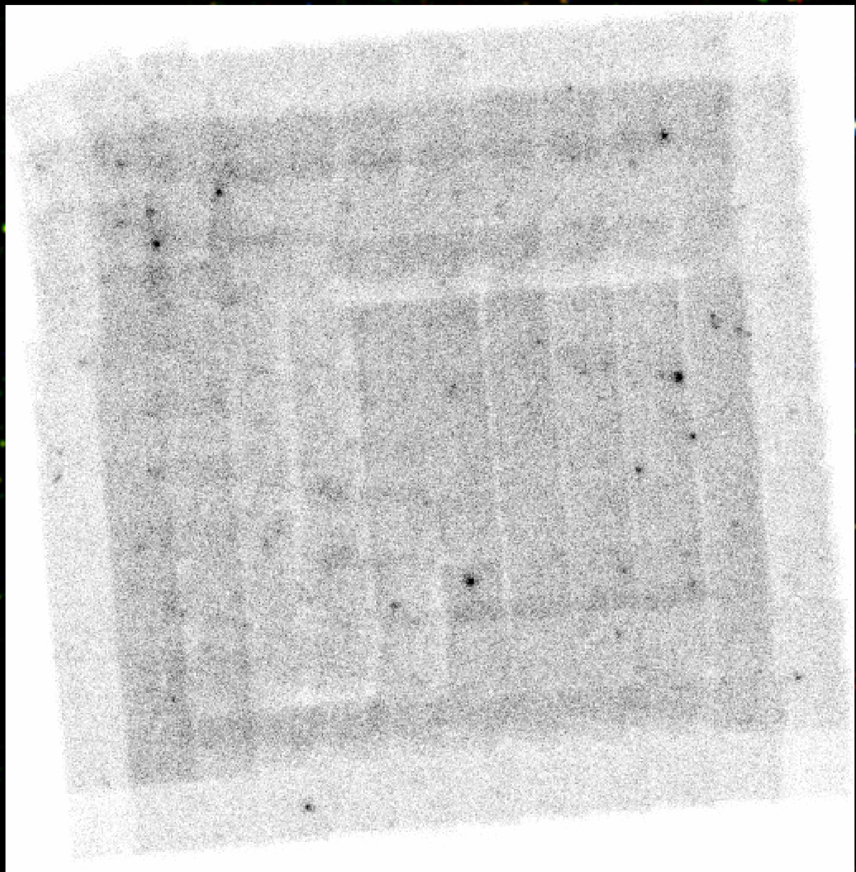
- Model for Nustar and broad band unabsorbed fits ($N_H < 10^{22}$ cm^{-2}):

  absorbed power-law + Fe Kα + Compton reflection (model A)

- Model for broad-band fits for absorbed ($N_H >$ ~10^{22} cm^{-2}) sources

  Scattered power-law + absorbed power-law + Fe Kα + Compton reflection (model B)

NuSTAR COSMOS survey

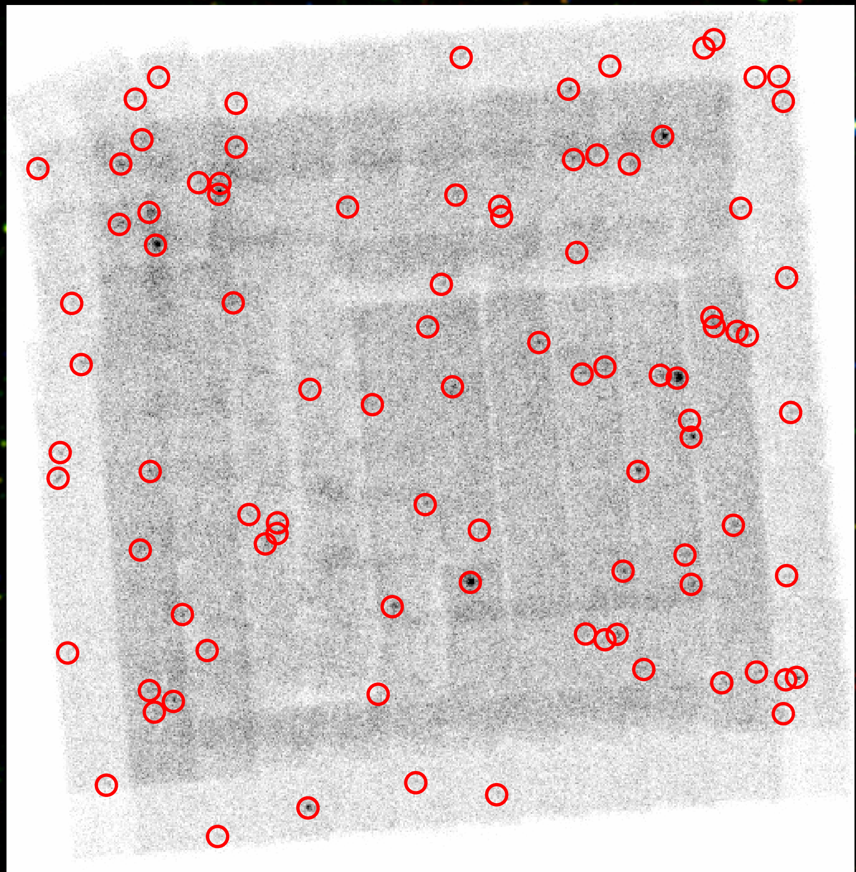


- 1.7 deg^2 → same area covered by Chandra XVP (PI: F. Civano) just completed
- 2 observing periods: 2013 and 2014

- 3.2 Ms exposure
- 20-30 ks exposure/tile
- 121 tiles (11x11 grid with half field shift)
- 100ks uniform depth on 1.1 deg^2

Civano et al. in prep.

NuSTAR COSMOS survey



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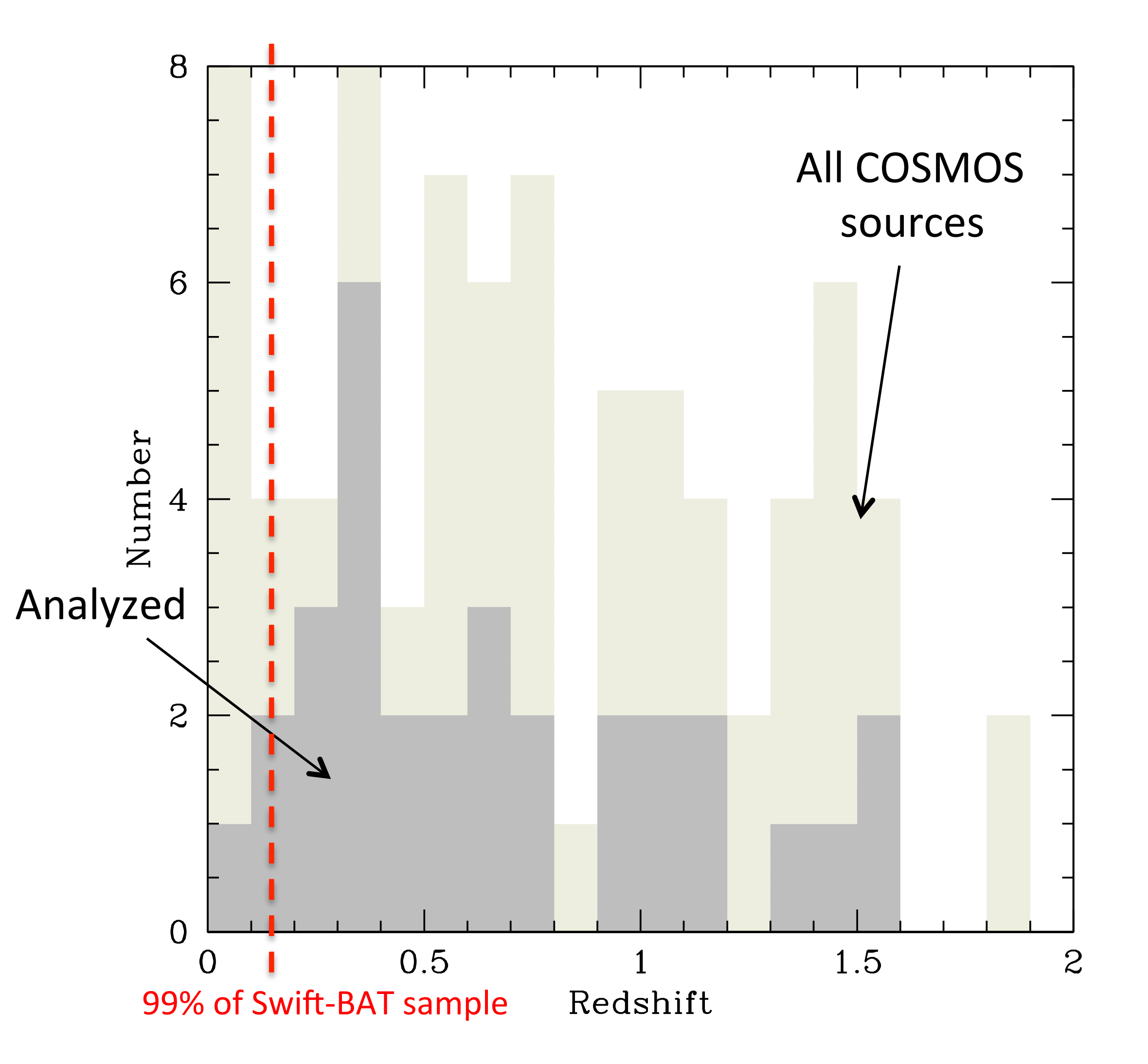
- 100ks uniform depth on 1.1 deg^2

91 sources detected

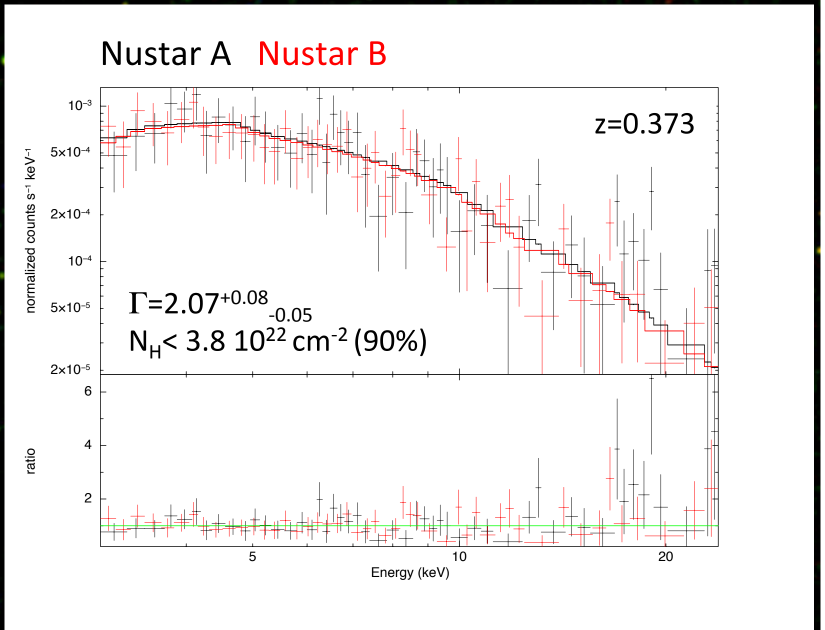
Civano et al. in prep.

Redshift distribution

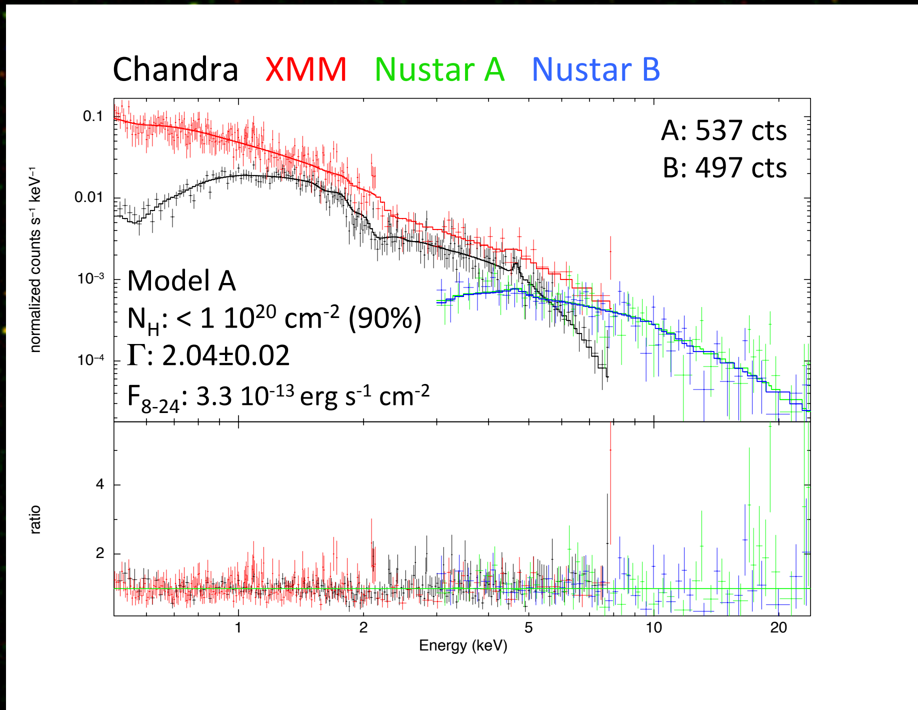


Spectra: low-N_H low-z source

Nustar only

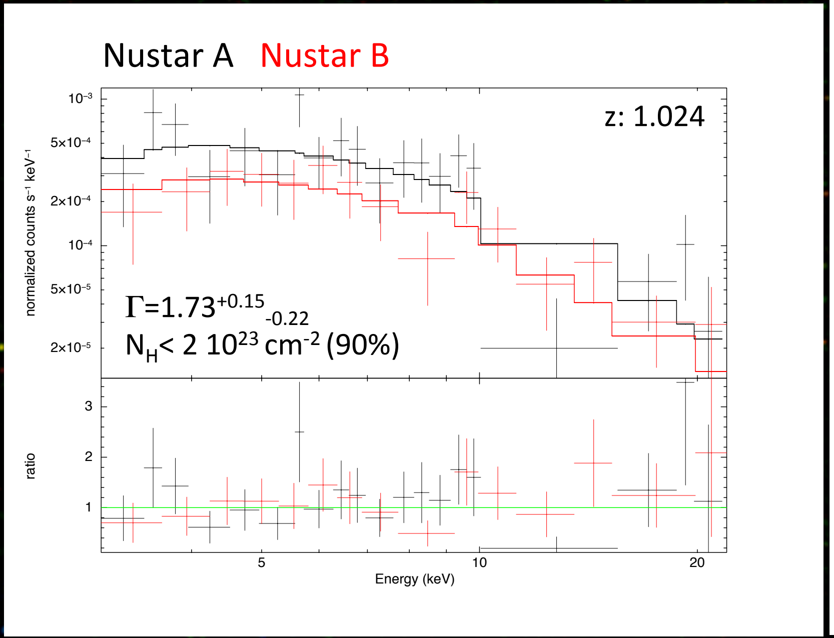


Broad band Nustar+Chandra+XMM

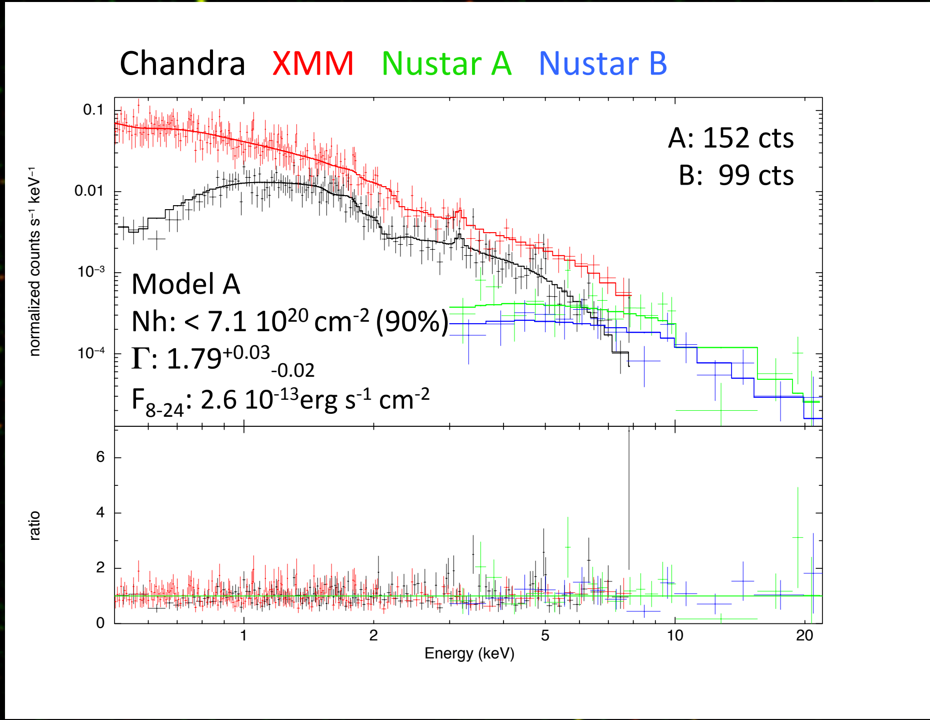


Spectra: low-N_H high-z source

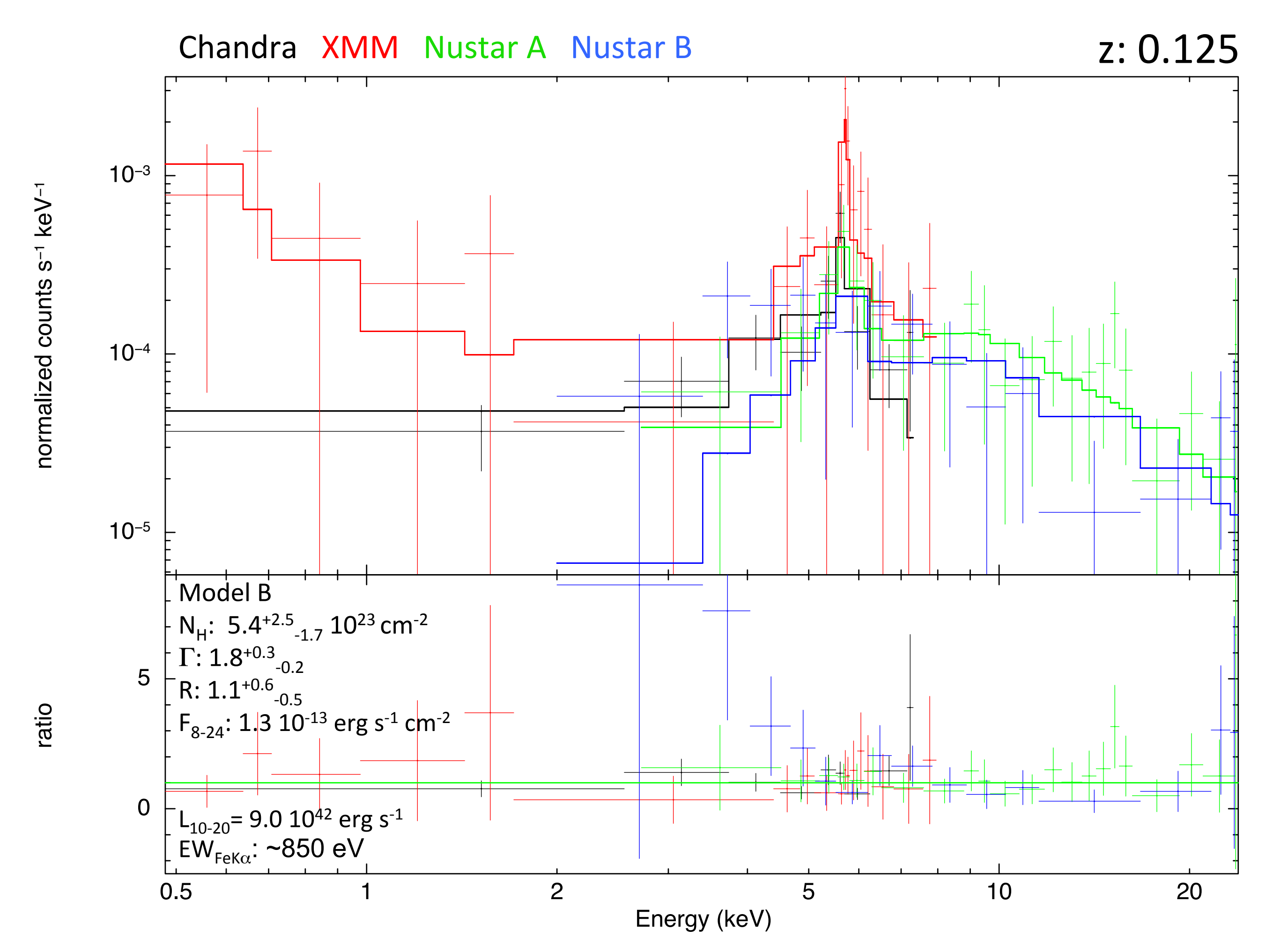
Nustar only



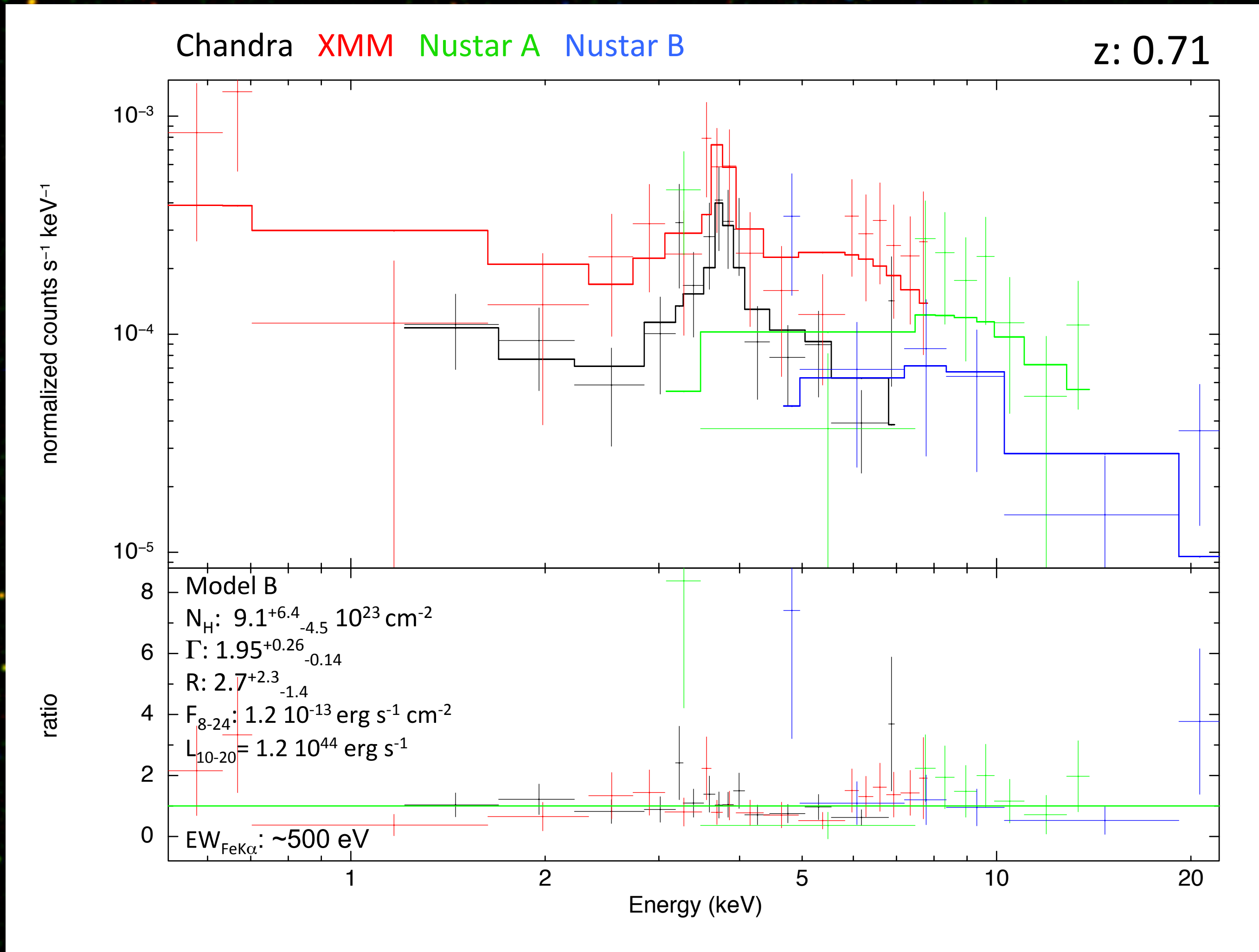
Broad band Nustar+Chandra+XMM



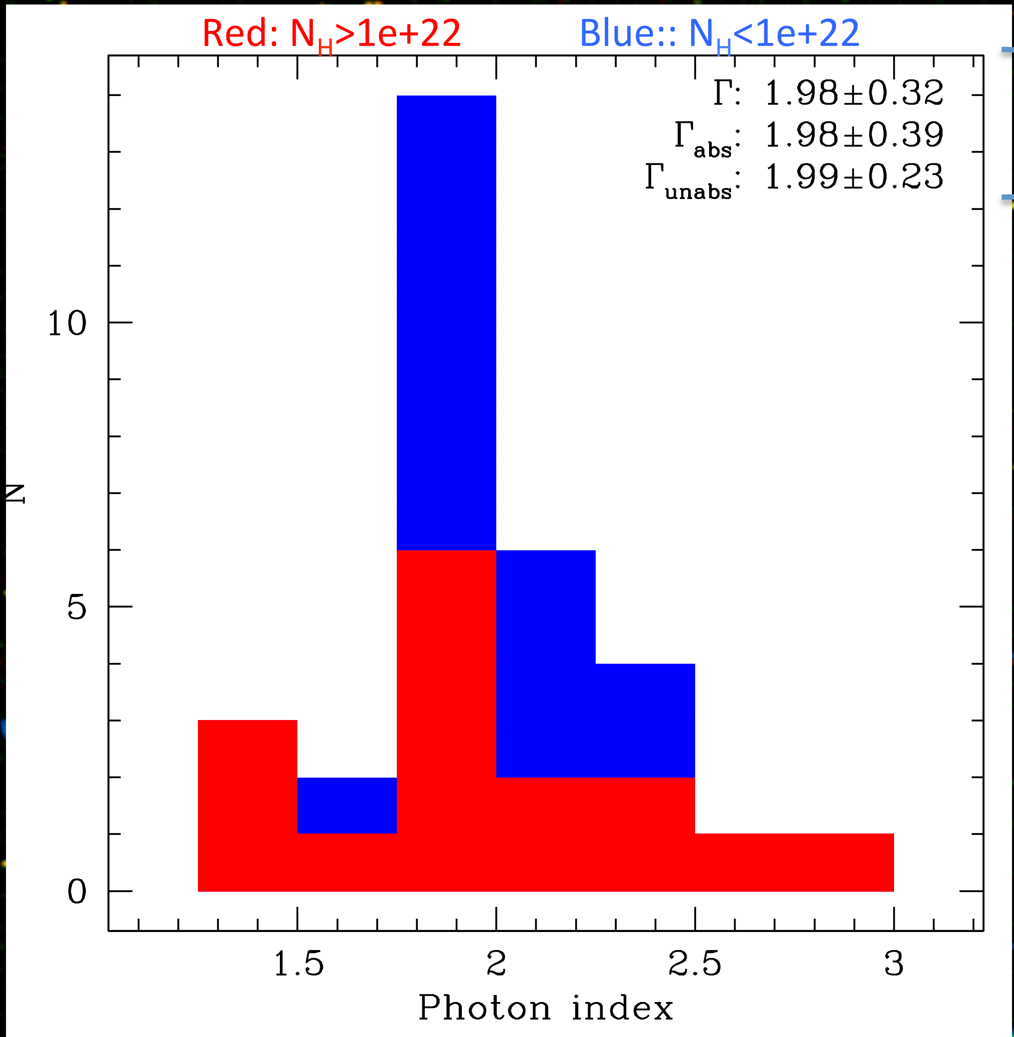
Heavily absorbed sources



Heavily absorbed sources

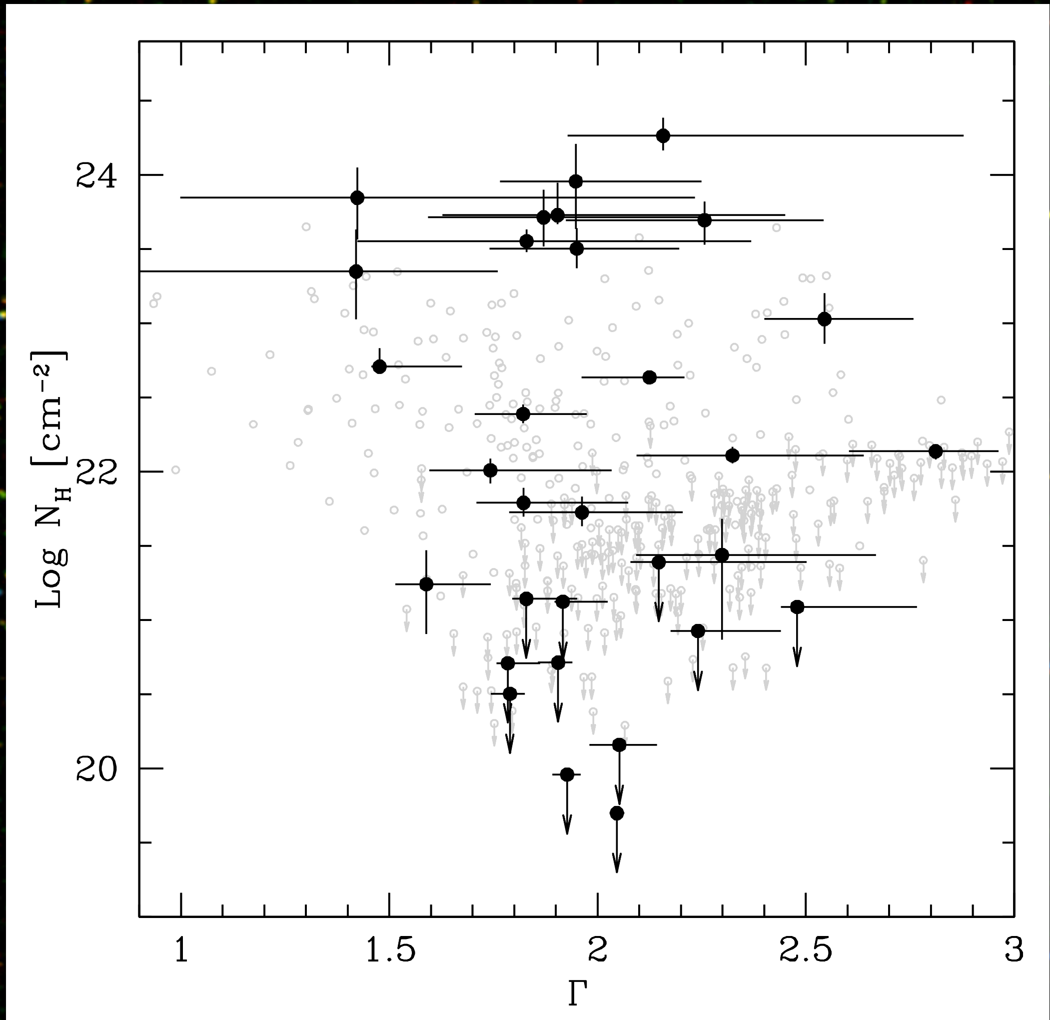


Photon index distribution



No difference btw absorbed and unabsorbed

Photon index vs N_H

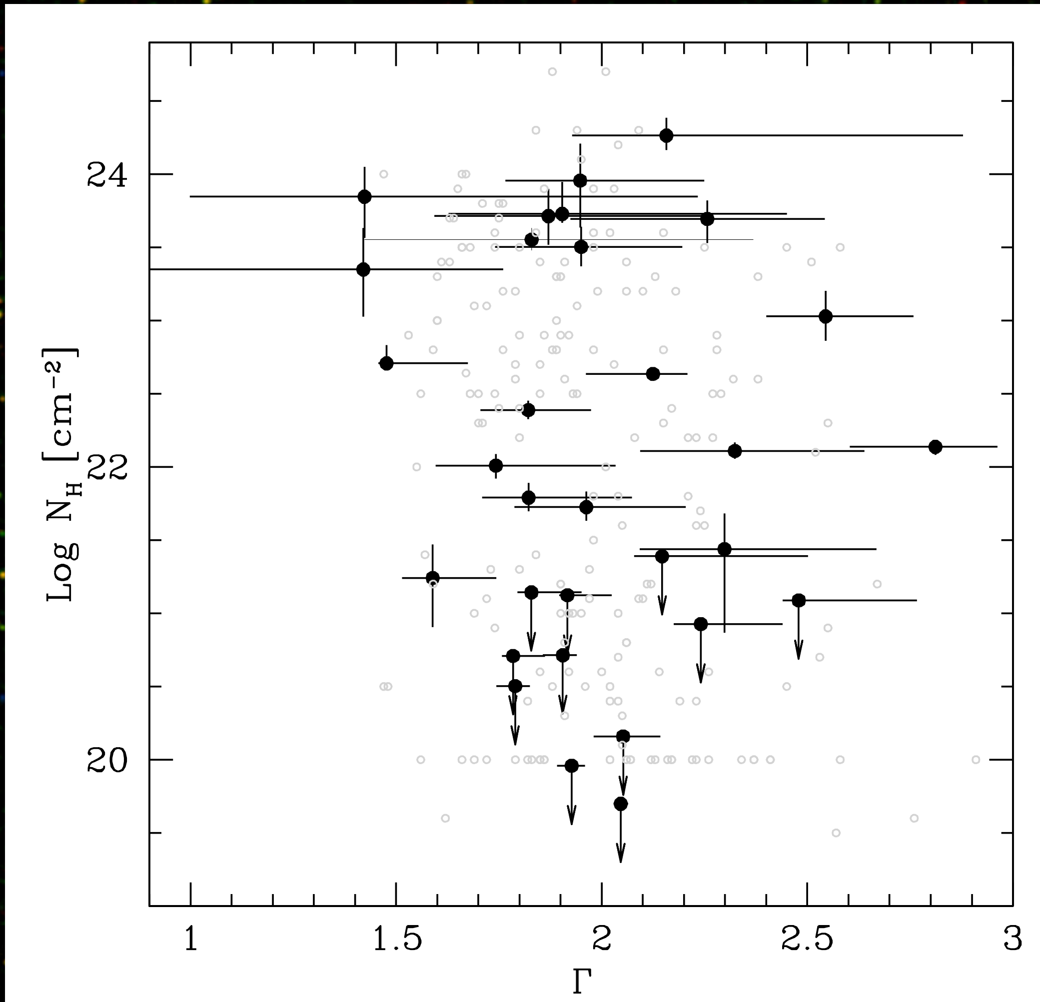


Chandra:
N_H>1e+23 cm^{-2} → 8%

Nustar:
N_H>1e+23cm^{-2} → 32%

Grey objects are Chandra from Lanzuisi et al. 2013

Photon index vs N_H

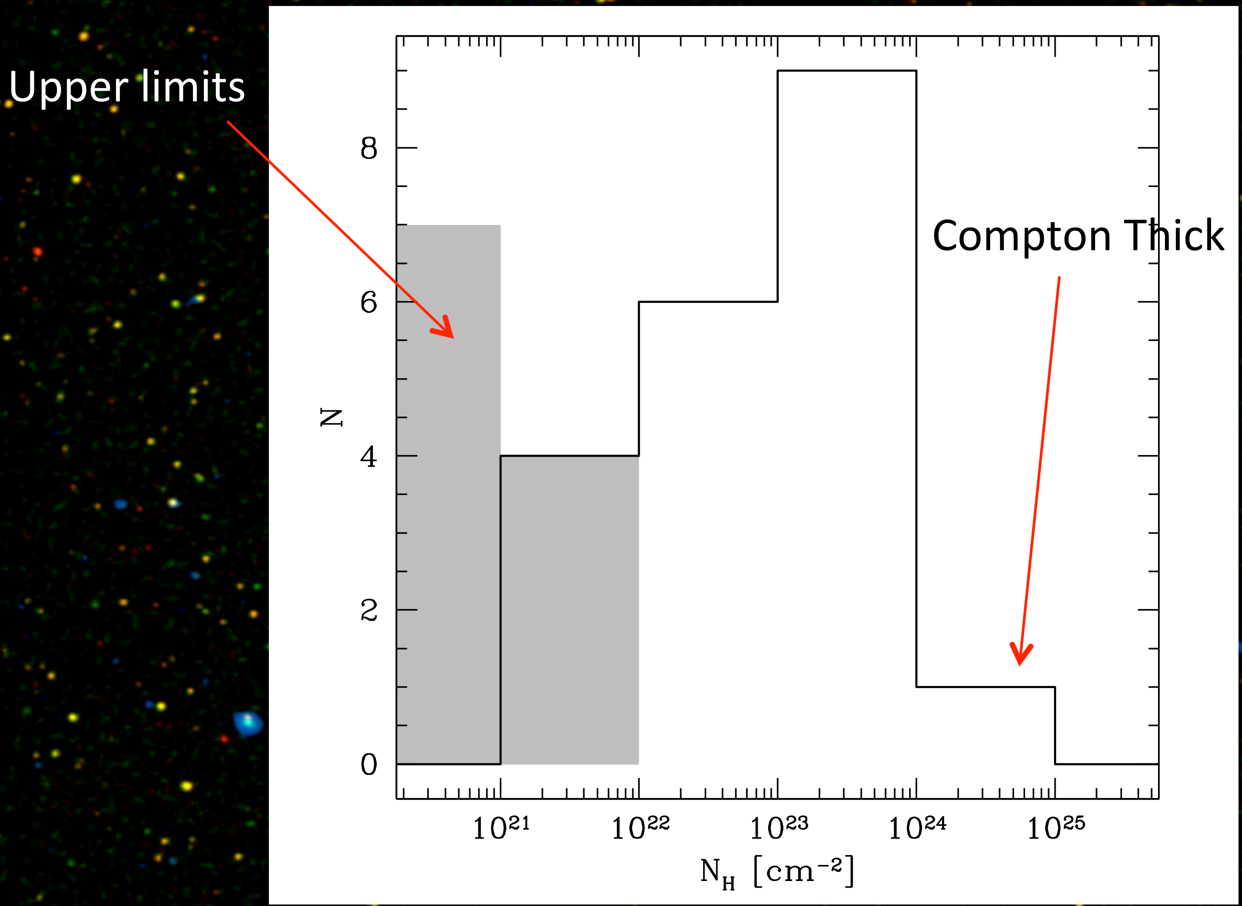


Swift-BAT:
N_H>1e+23 cm^{-2} → 30%

Nustar:
N_H>1e+23 cm^{-2} → 32%

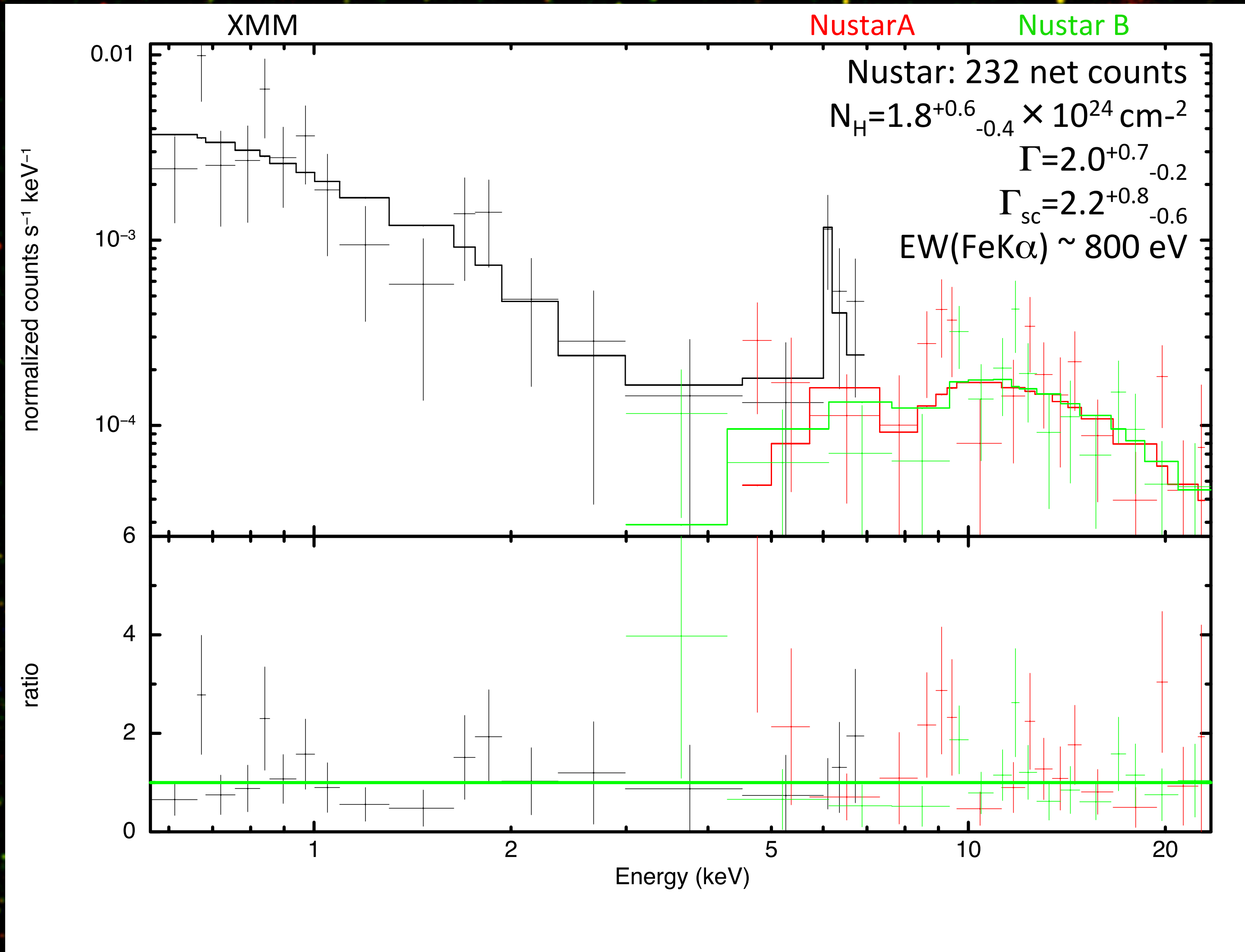
Grey objects are SWIFT-BAT from Burlon et al. 2011

Column density distribution



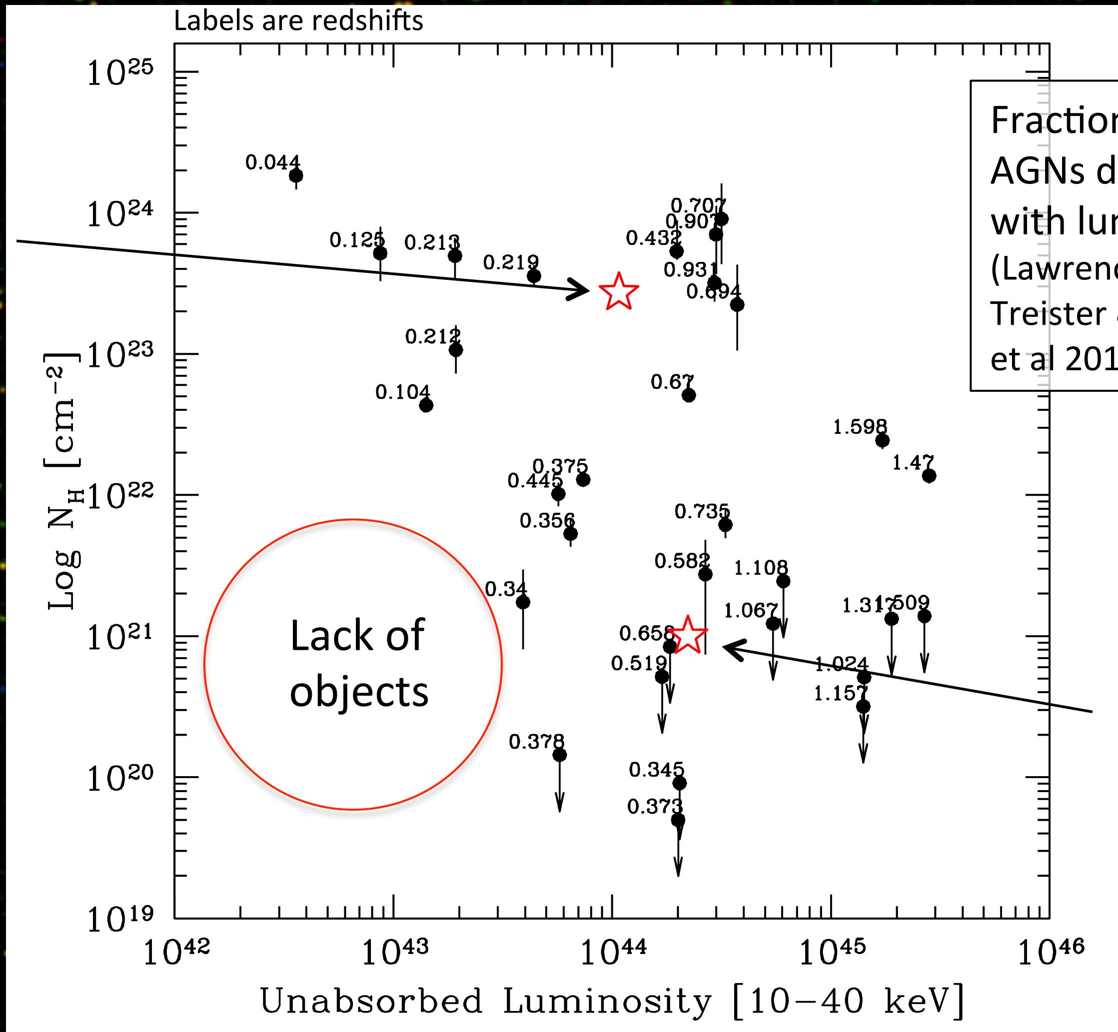
- N_H>1e+23 cm^{-2} → 10/31 = 32%
- N_H<1e+23 cm^{-2} → 21/31 = 68%

The Compton thick source (z=0.044)



Luminosity vs. absorption

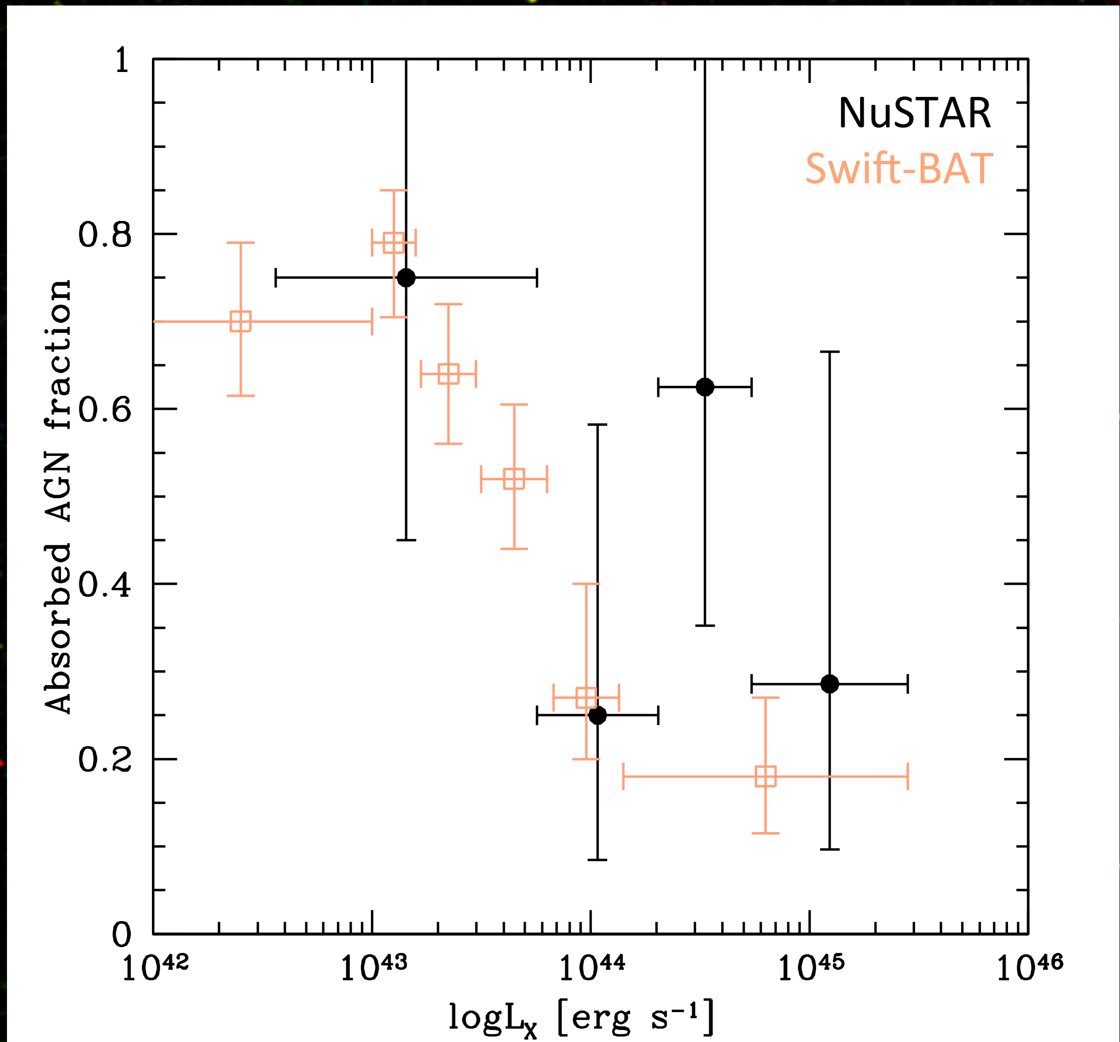
Median luminosity
For absorbed
1.4×10^{44} erg s^{-1}



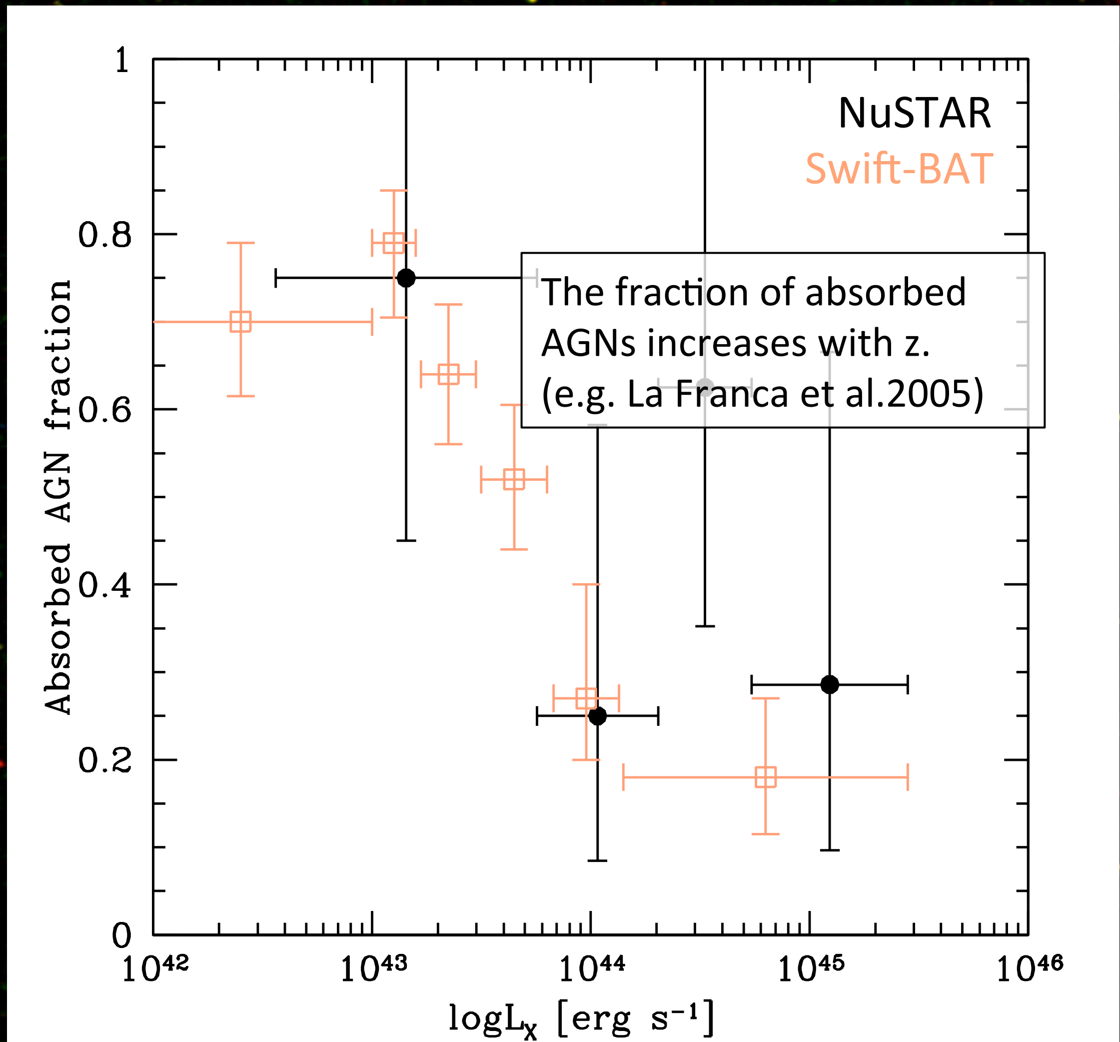
Fraction of obscured AGNs decreases with luminosity (Lawrence & Elvis 1982, Treister & Urry 2006, Brusa et al 2010)

Median luminosity
for unabsorbed
2.8×10^{44} erg s^{-1}

Fraction of absorbed AGNs

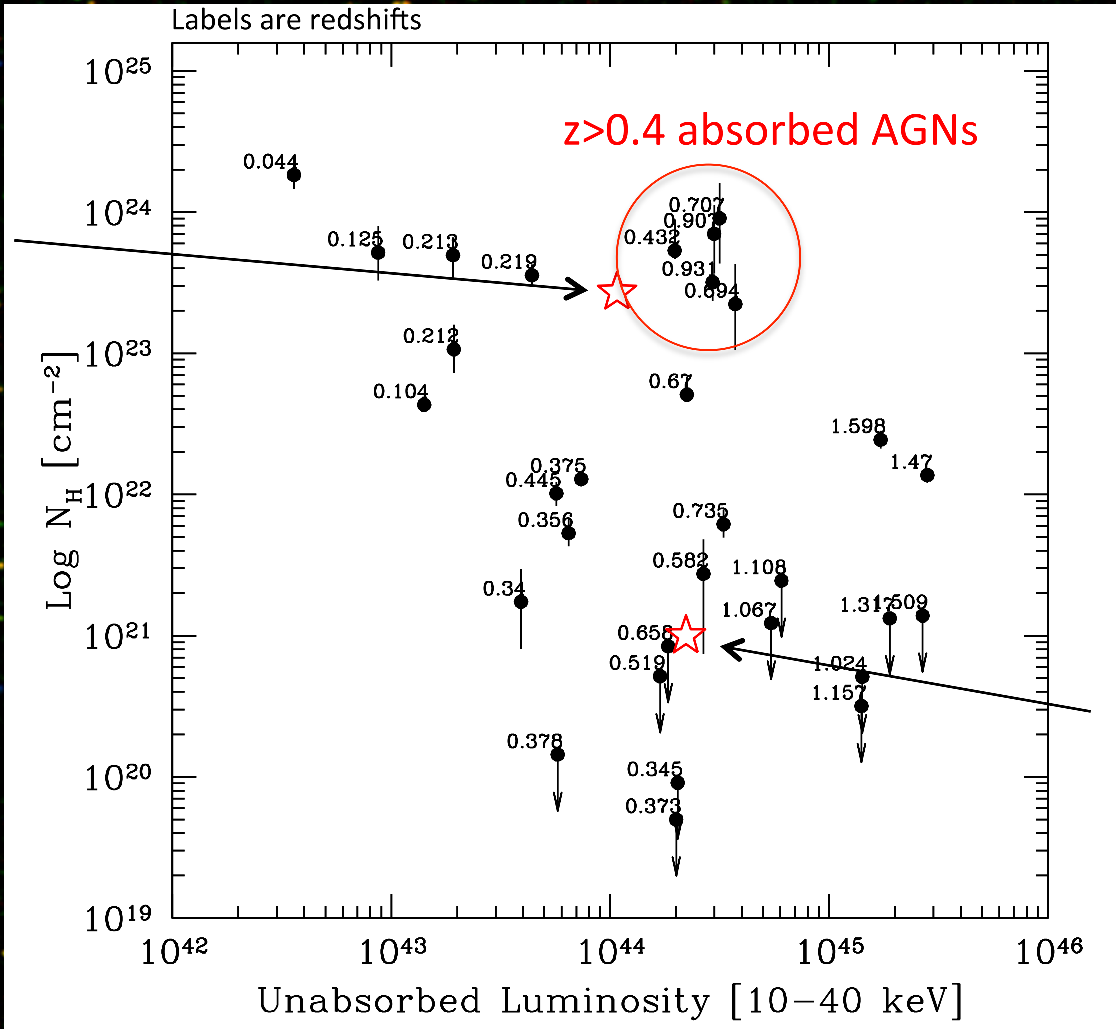


Fraction of absorbed AGNs



Luminosity vs. absorption

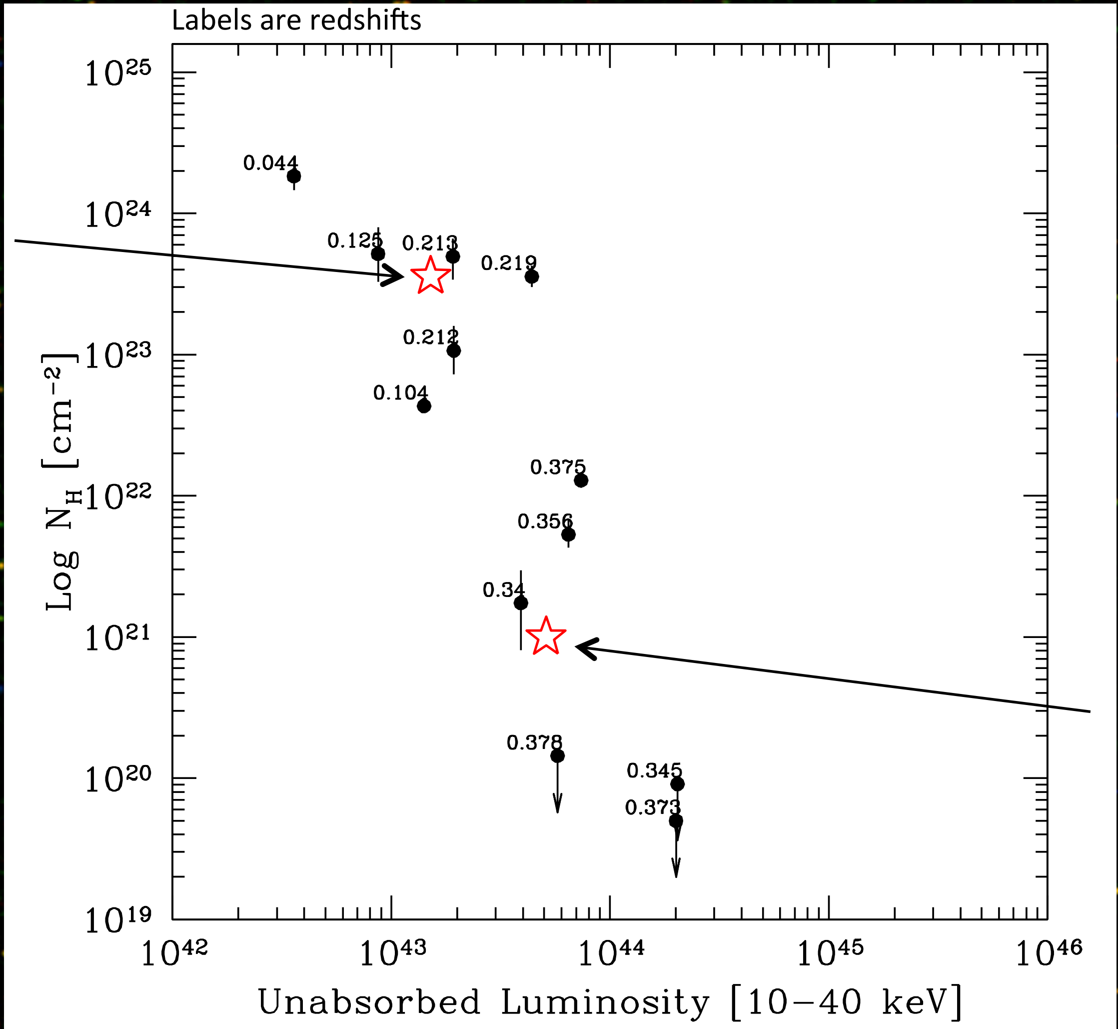
Median luminosity for absorbed 1.4×10^{44} erg s^{-1}



Median luminosity for unabsorbed 2.8×10^{44} erg s^{-1}

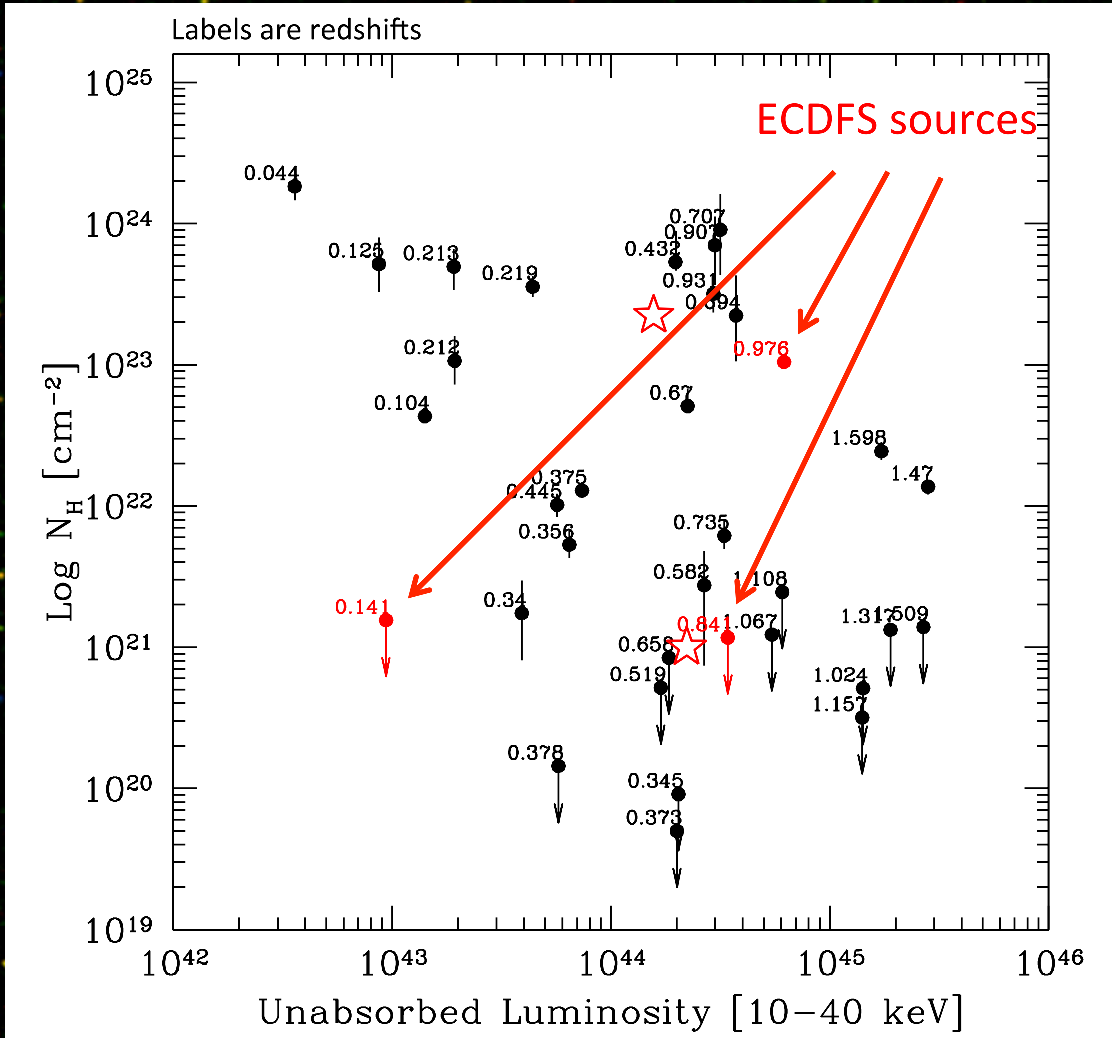
Luminosity vs. absorption

Median luminosity for absorbed 1.9×10^{43} erg s^{-1}



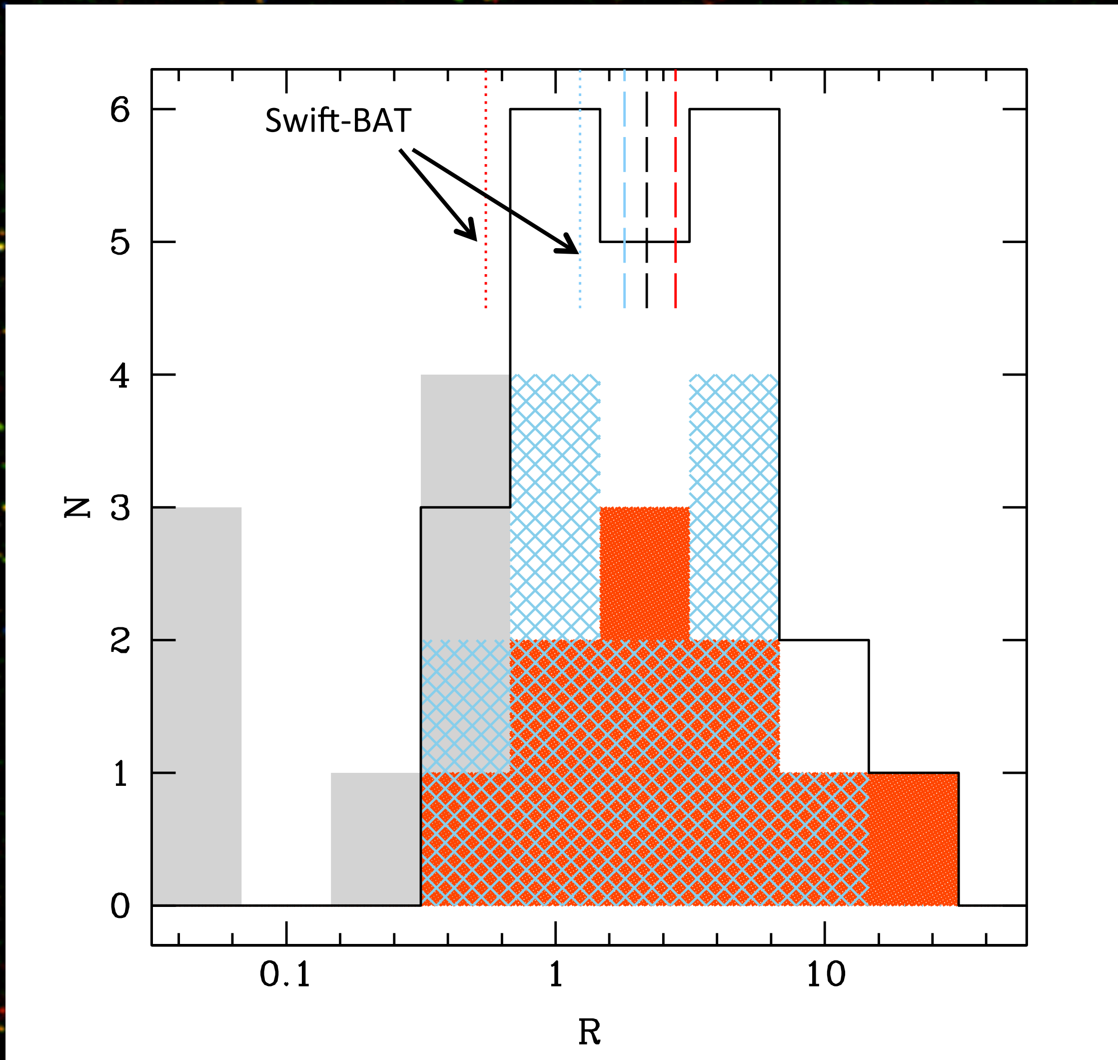
Median luminosity for unabsorbed 6.4×10^{43} erg s^{-1}

Luminosity vs. absorption



Reflection component

Red: > 10^{22}cm^{-2} Blue: < 10^{22}cm^{-2}



Conclusions

- Bright hard (8-24 keV) X-ray selected sample in COSMOS+ECDFS (the most significantly detected sources)
- Sample of 35 non local (z>0.1) AGNs
- Ongoing broad band (0.5-24 keV) spectral analysis for the (XMM-Chandra-Nustar)
- Characterization of the spectral properties:
  - Γ: ~2+/-0.3
  - N_H: so far ~30% of highly obscured sources (1 of which Compton Thick)
  - R: mean value ~2-3 with large scatter (consistency with SWIFT-BAT)
  - Slight tendency for AGN absorbed fraction decrease with L_X (probably the redshift dependence is somewhat masking this trend)