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Title	Investigating the origin of X-ray variability through XMM-Newton and WISE data
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ABSTRACT

An efficient diagnostic method to find local ($z < 0.1$) Compton-thick AGN consists in selecting sources characterized by hard X-ray colors and low X-ray to mid-IR flux ratio (HR vs. F_X/F_{IR}). This has been done efficiently in the past using 2XMM and IRAS data (Severgnini et al. 2012). I will here summarize my master thesis work, in which I tested the stability of the method outlined above using the latest 3XMM and WISE data, and I investigated its potentialities in finding interesting spectrally variable (including changing-look) XMM-Newton sources.

Diagnostic diagram for AGN classification in the local Universe: HR vs. F_X/F_{IR}

"Threshold" values:

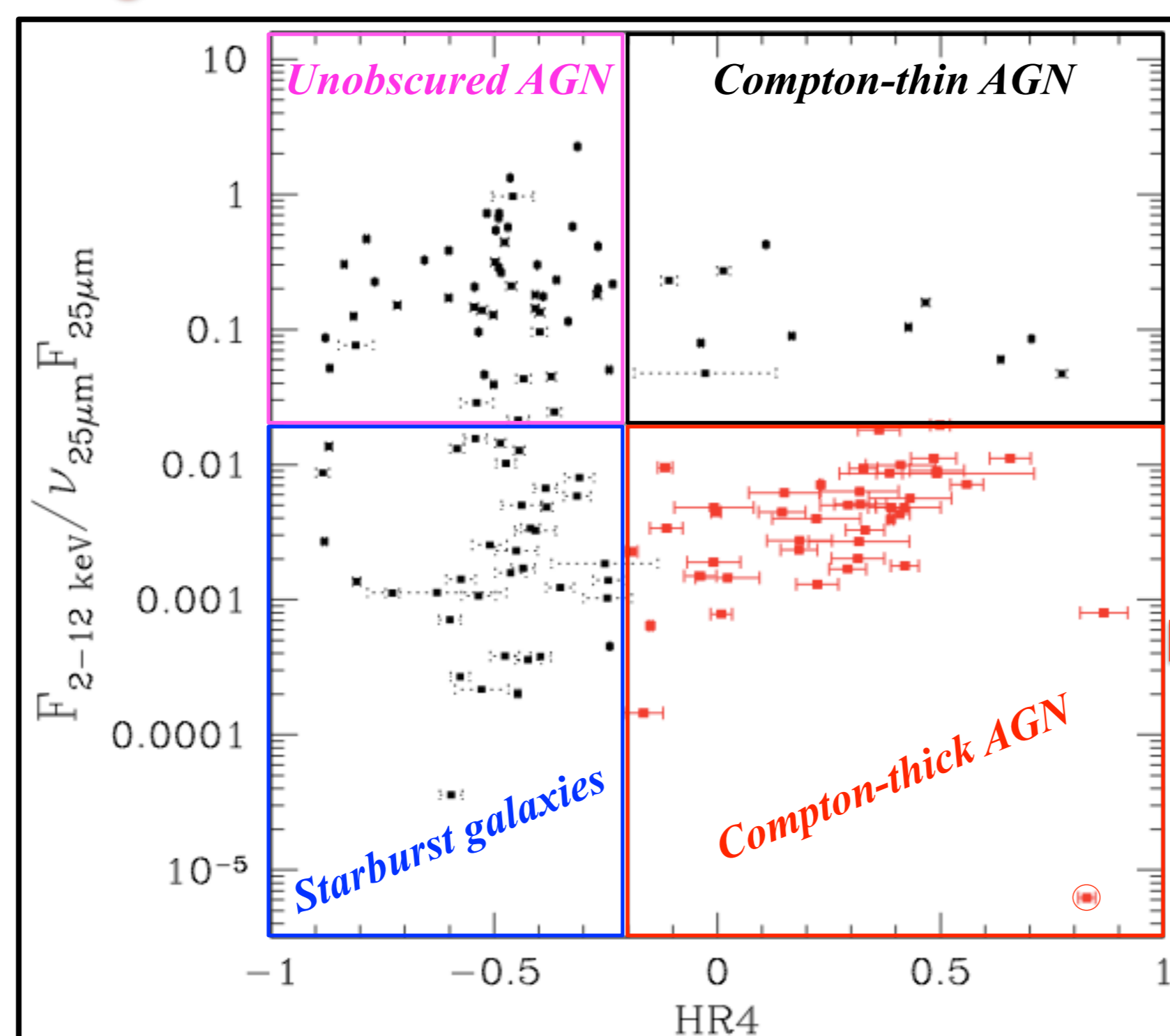
◆ $\frac{F_X}{v_{IR}F_{IR}} < 0.02$ and $HR4 < -0.2$

◆ $\frac{F_X}{v_{IR}F_{IR}} > 0.02$ and $HR4 < -0.2$

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$$HR4 = \frac{cts(4.5-12 \text{ keV}) - cts(2-4.5 \text{ keV})}{cts(4.5-12 \text{ keV}) + cts(2-4.5 \text{ keV})}$$



Original sample: 145 sources obtained cross-correlating the IRAS PSC with the 2XMMi-DR2 slim catalogue (Figure 1)

UPDATING the information (positions, fluxes, HR) of the original sample using the most recent 3XMM-DR5 and AllWISE source catalog (see Table 1)

THIS WORK: 141 sources* of the original sample

*The exclusion of 4 sources is due to the lack of a WISE detection at 22 micrometers or to a mismatch between the X-ray and mid-IR emission

Table 1. Comparison between the different catalogues.

	X-ray emission	
	2XMMi-DR2	3XMM-DR5
Number of revolutions	4117	7781
Number of unique sources	221012	396910
Sky coverage	420 deg ²	877 deg ²
	IR emission	
	IRAS PSC	AllWISE
Number of unique sources	245889	747634026
PSF (25 micrometers / 22 micrometers)	1' x 5'	12"
Sensitivity (25 micrometers / 22 micrometers)	650 mJy @ 10 sigma	2.6 mJy @ 5 sigma

Surface density of Compton-thick AGN: $\rho^{CT}(F_{25\mu m} > 0.5 \text{ Jy}) \sim 3 \times 10^{-3} \text{ src deg}^{-2}$ (Severgnini et al. 2012)

Figure 1. The X-ray to mid-IR flux ratio vs. hardness ratio diagnostic diagram with 2XMM and IRAS data (Severgnini et al. 2012).

RESULTS

① Stability of the diagnostic diagram in classifying sources considering their average properties

Only 7 sources have shown transitions within the diagram

② Confirmation of the past results (e.g. surface density of CT AGN)

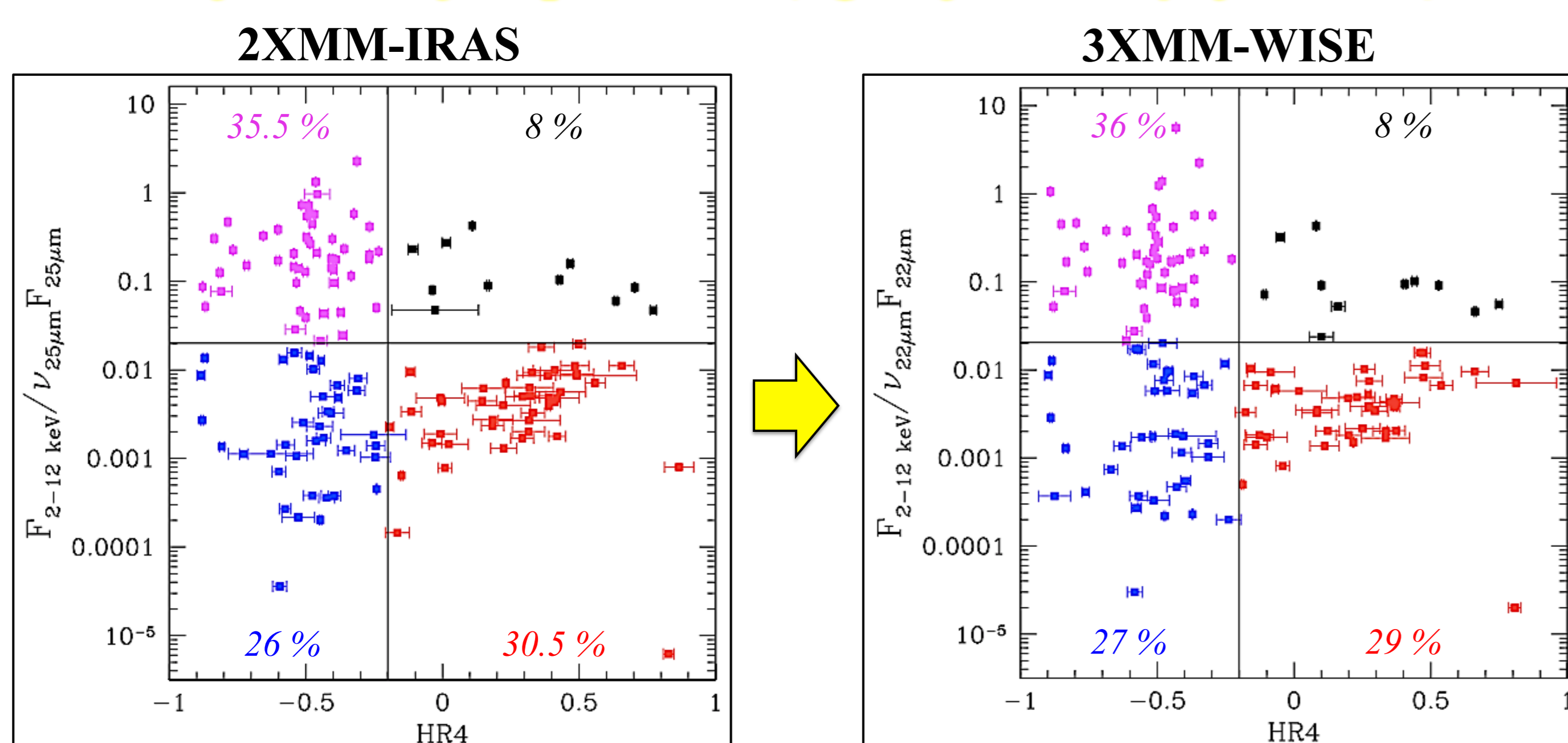


Figure 2. 2XMM-IRAS (left panel) and 3XMM-WISE (right panel) diagnostic diagram. The color code identifies the regions in which the probability to find starburst galaxies (blue symbols), unobscured, Compton-thin and Compton thick AGN (magenta, black and red symbols, respectively) is maximized.

③ Selection of interesting spectrally variable X-ray sources

The availability of multiple observations in the 3XMM catalogue for ~54% of the sample has allowed us to extend the use of the diagnostic diagram to *variable AGN* by plotting individual observations we identified some interesting sources showing transitions between different regions of the diagnostic diagram (i.e. *changing-look AGN* – see Figure 3).

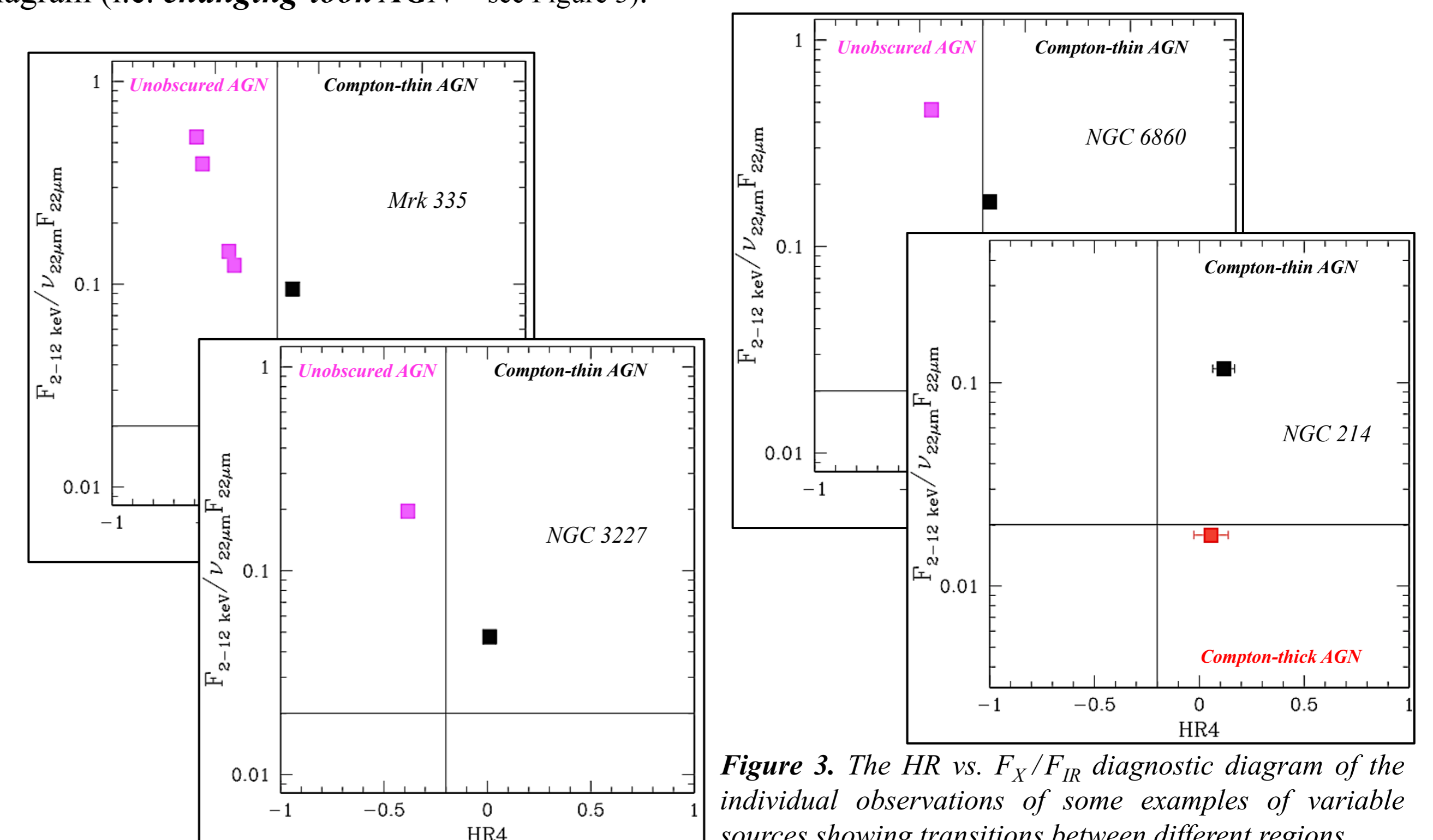


Figure 3. The HR vs. F_X/F_{IR} diagnostic diagram of the individual observations of some examples of variable sources showing transitions between different regions.

④ Diagnostic diagram as a tool to have hints on the origin of the observed X-ray variability

➤ NGC 6860: Seyfert 1/1.5 (Hiroi et al. 2013 / Lipari et al. 1993) at $z=0.015$

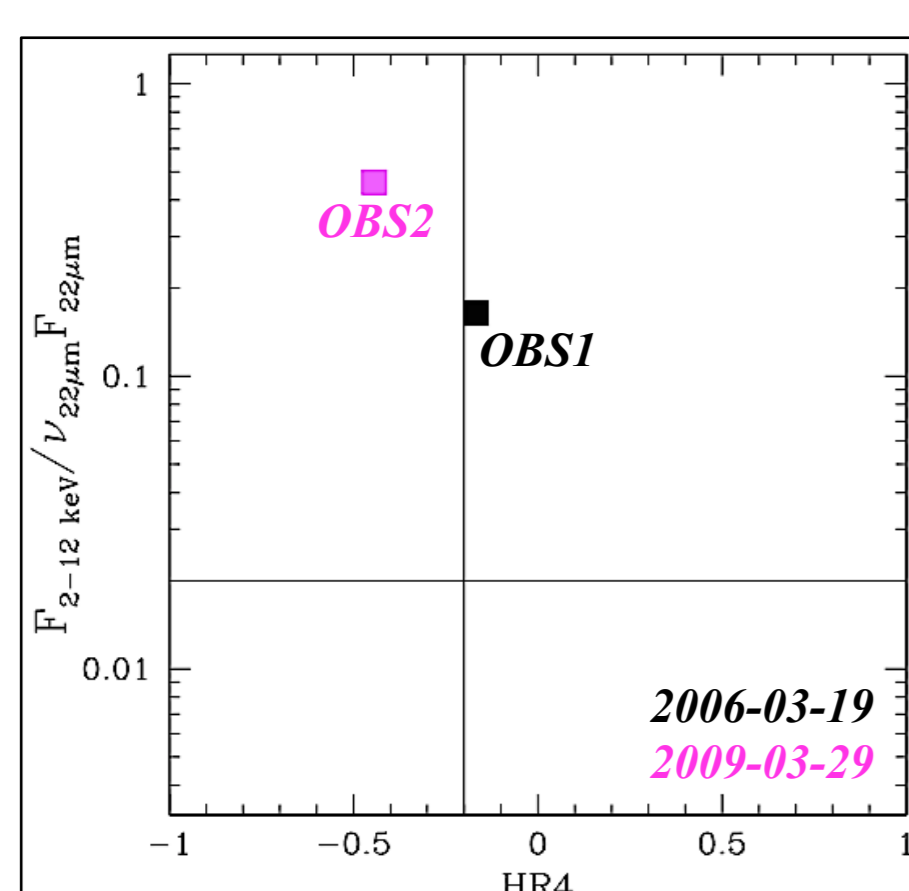


Figure 4. The HR vs. F_X/F_{IR} diagnostic diagram showing the position of the two observations of NGC 6860.

HINT: a significant variation in HR points out a dramatic change in the column density of the neutral gas along the line of sight

CONFIRMED BY SPECTRAL ANALYSIS

X-ray variability driven by the crossing along the line of sight of a neutral cloud covering about 80% of the radiation emitted by the AGN (see Figure 5)

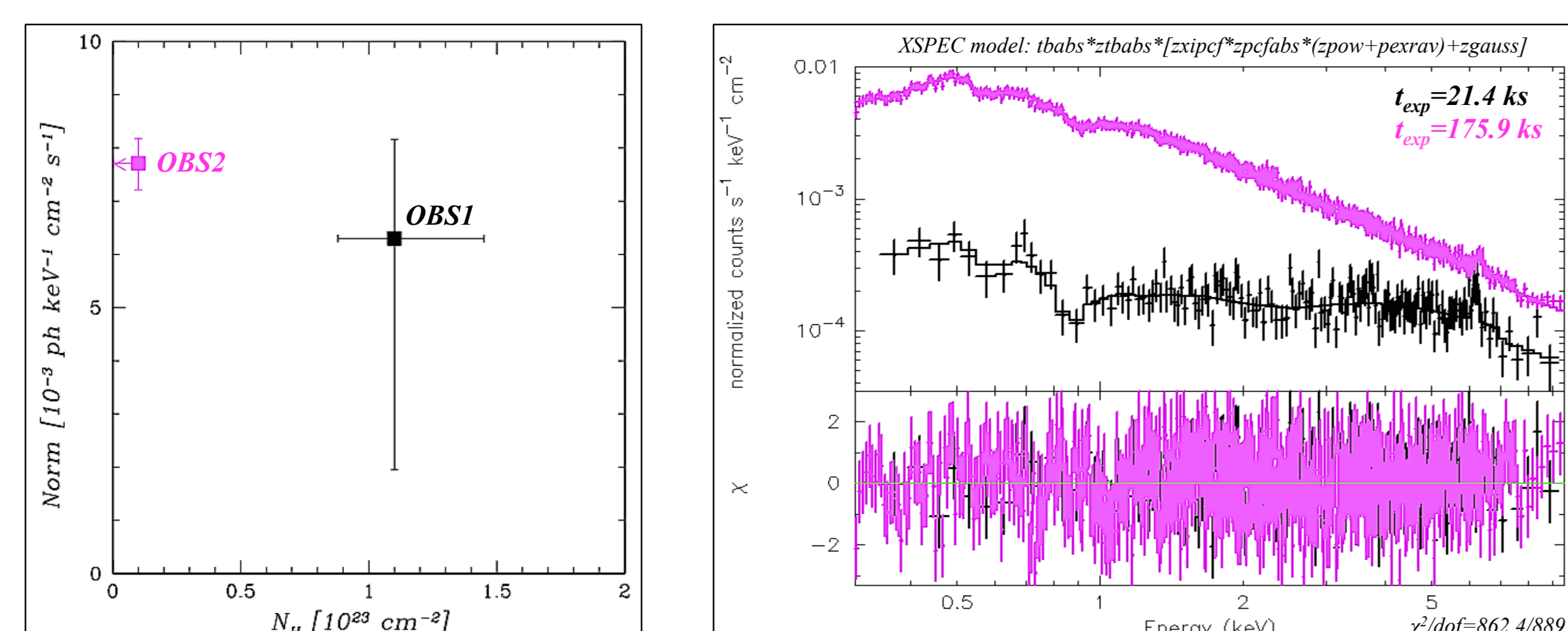


Figure 5. Values of the neutral gas column density as a function of the normalization of the intrinsic power law in OBS1 and OBS2 (black and magenta square, respectively) of NGC 6860 (left panel) obtained from the X-ray simultaneous fit (right panel).

➤ NGC 4388: Seyfert 2 (Bottacini et al. 2012) at $z=0.00842$

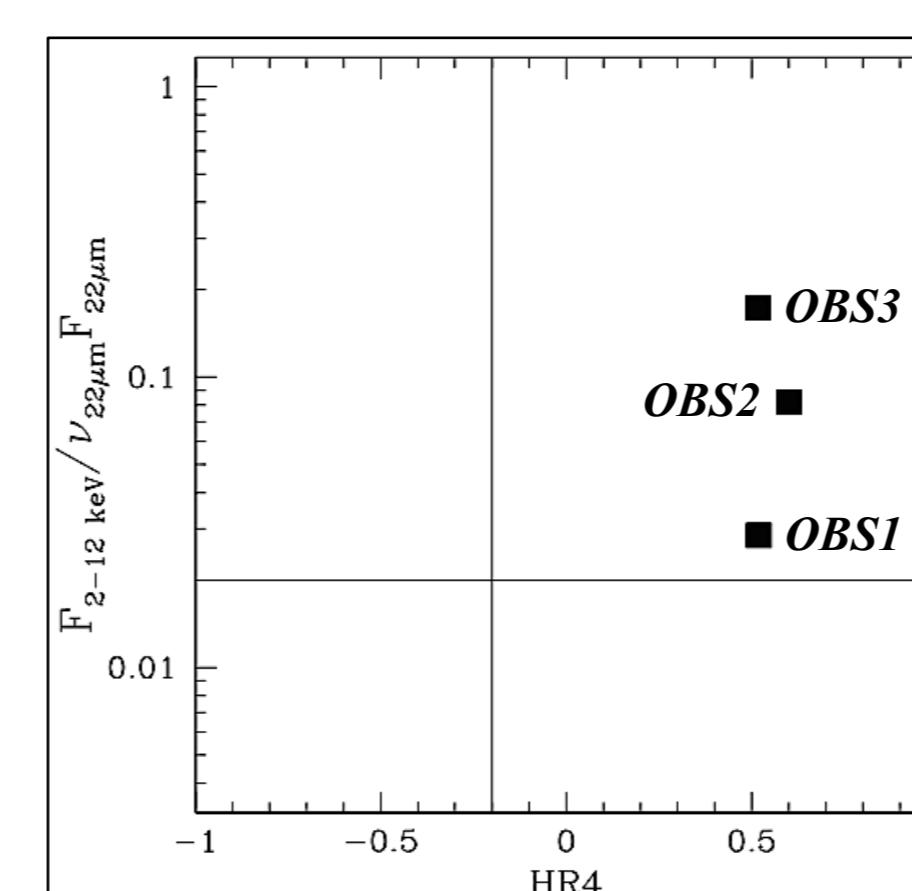


Figure 6. The HR vs. F_X/F_{IR} diagnostic diagram showing the position of the three observations of NGC 4388.

HINT: the X-ray variability is due to an increasing in the intrinsic emission of the AGN

CONFIRMED BY SPECTRAL ANALYSIS

Although a little variation in N_H is clearly visible (see Figure 7), the main driver of the X-ray variability is a significant increase of the AGN intrinsic emission.

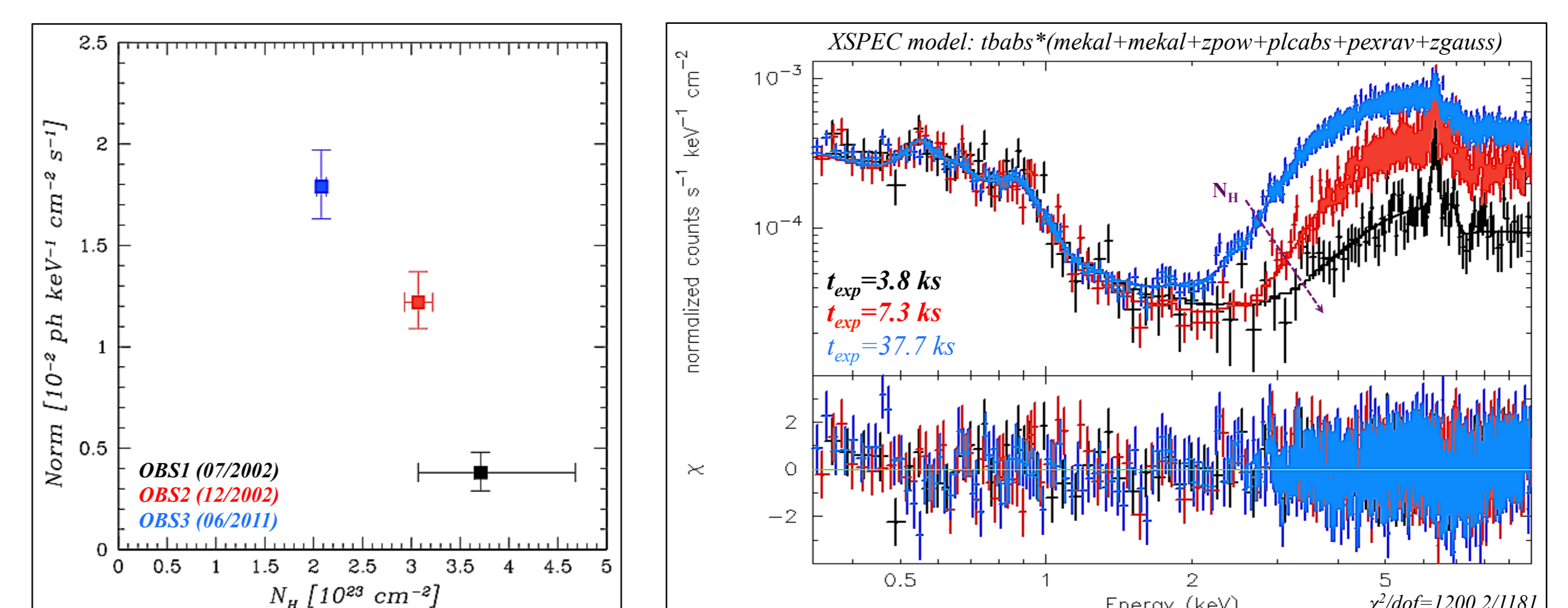


Figure 7. Values of the neutral gas column density as a function of the normalization of the intrinsic power law in OBS1, OBS2 and OBS3 (black, red and blue square, respectively) of NGC 4388 (left panel) obtained from the X-ray simultaneous fit (right panel).

Zaino et al. in preparation

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