THE ISM AS SEEN IN X-RAY OBSERVATIONS

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ABSTRACT

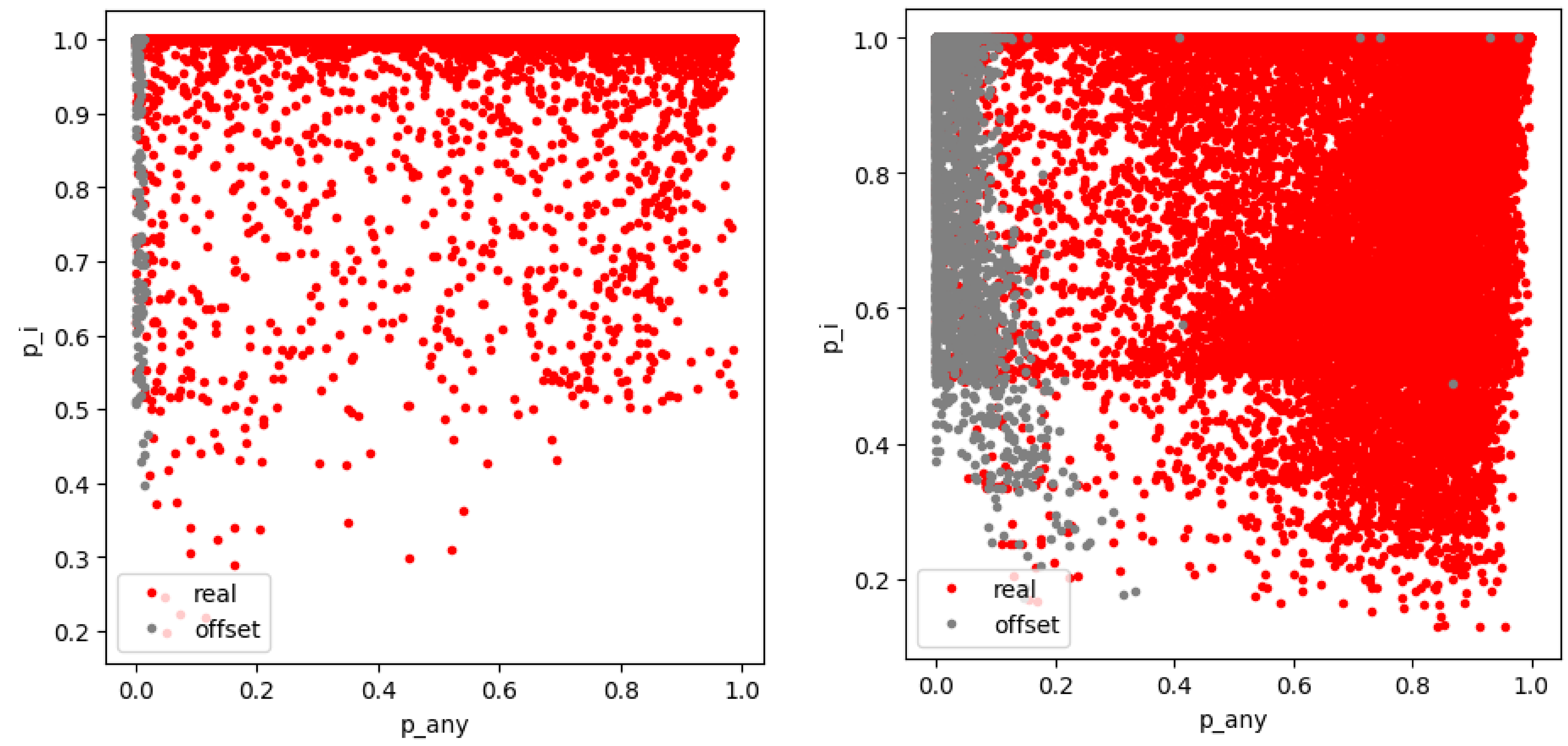
The interstellar medium (ISM), gas and dust between stars, is an important constituent of galaxies, affecting star formation and their overall evolution. A powerful technique to study such environment is through X-ray observations because, due to their high energy, X-ray photons can trace simultaneously the cold-warm-hot phases of the ISM, including molecular and solid components. Here, we report on the 3D mapping of the neutral X-ray absorption in the ISM using X-ray data from both Chandra and XMM-Newton, in combination with distances obtained with the GAIA observatory.

THE SOURCES SAMPLE

In order to create the galactic sample we use the following catalogues:

- *To obtain X-ray spectra:* The XMM-Newton source catalog (3XMM-DR8) and the Chandra Source Catalog (CSC 2.0)
- *To obtain source distances:* the GAIA catalog (GAIA DR2)
- *To select only stars:* the guide star catalog II (GSC II)

The cross-matching between the three catalogues has been done using the NWAY code (Salvato et al. 2018). NWAY is an statistics based algorithm which extends previous distance and sky density based association methods and, using one or more priors (e.g. colours, magnitudes), weights the probability that sources from two or more catalogues are simultaneously associated on the basis of their observable characteristics.



"p_i" versus "p_any" distribution for the correct counterparts to the Chandra/GAIA (left panel) and XMM-Newton/GAIA (right panel) sources (red points) and for the candidate counterpart to the same sources after randomizing their position (grey). Sources with "p_any<0.1" for Chandra and "p_any<0.2" for XMM-Newton and with ambiguous detection (i.e. match_flag==2) were not included in the cross-matching sample. After the crossmatching between GAIA and the X-ray catalogues we have identified 31244 Chandra unique sources and 52129 XMM-Newton unique sources.

X-RAY FITTING PROCEDURE

We used EPIC-pn and ACIS data for XMM-Newton and Chandra, respectively. Each spectrum has been rebinned to have, at least, 1 count per channel. The fits are done in the 0.5-10 keV energy band. For each source, in the case of multiple observations, the spectra with highest number of counts is fitted.

We fitted the spectra using multiple models (in XSPEC nomenclature):

- *tbabs∗powerlaw*
- *tbabs∗bbody*
- *tbabs∗apec*

The solar abundance is set to (Wilms et al. 2000). and the initial parameter for Nh is the 21 cm value from (Kalberla et al. 2005). Finally, Cash statistic (Cash 1979) is used in the spectral fits.

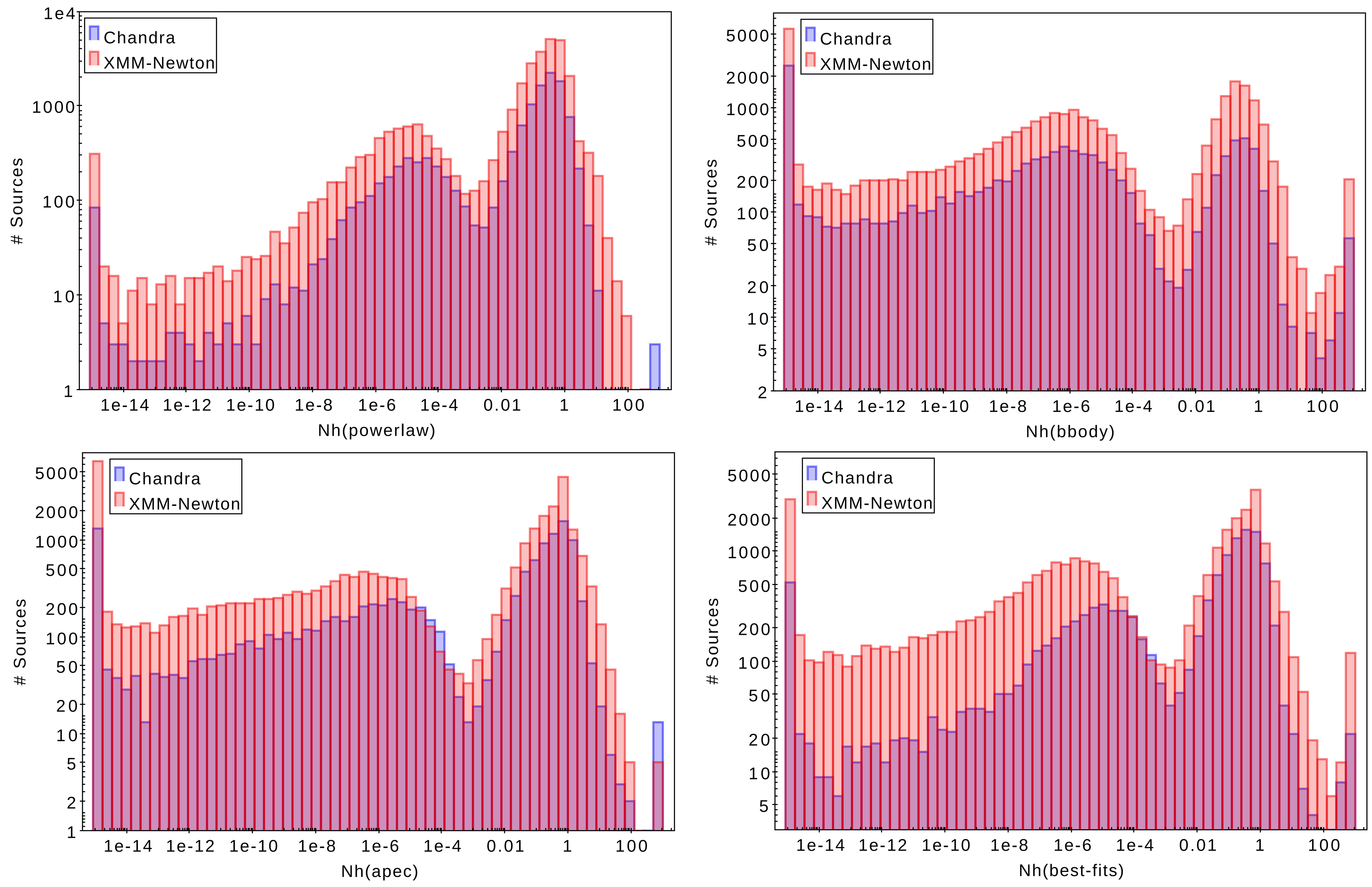


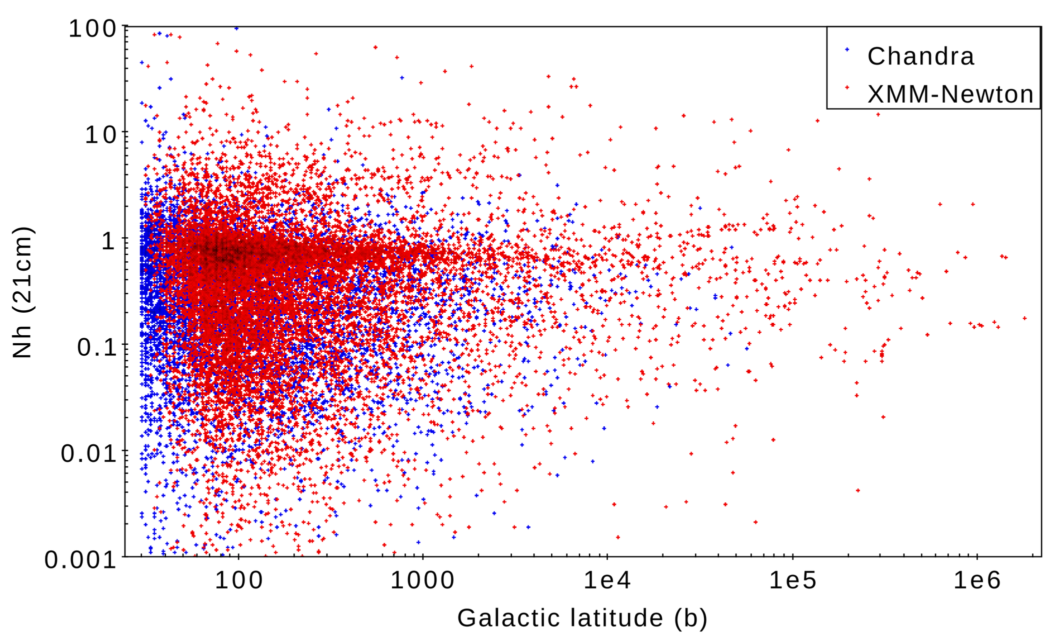
Figure shows the distribution of Nh for the powerlaw model (top left panel), the blackbody model (top right panel), the apec model (bottom left panel) and for the best-fit results (i.e. the fits with the best statistic, bottom right panel). Nh is shown in units of 10^{22} cm^{-2}

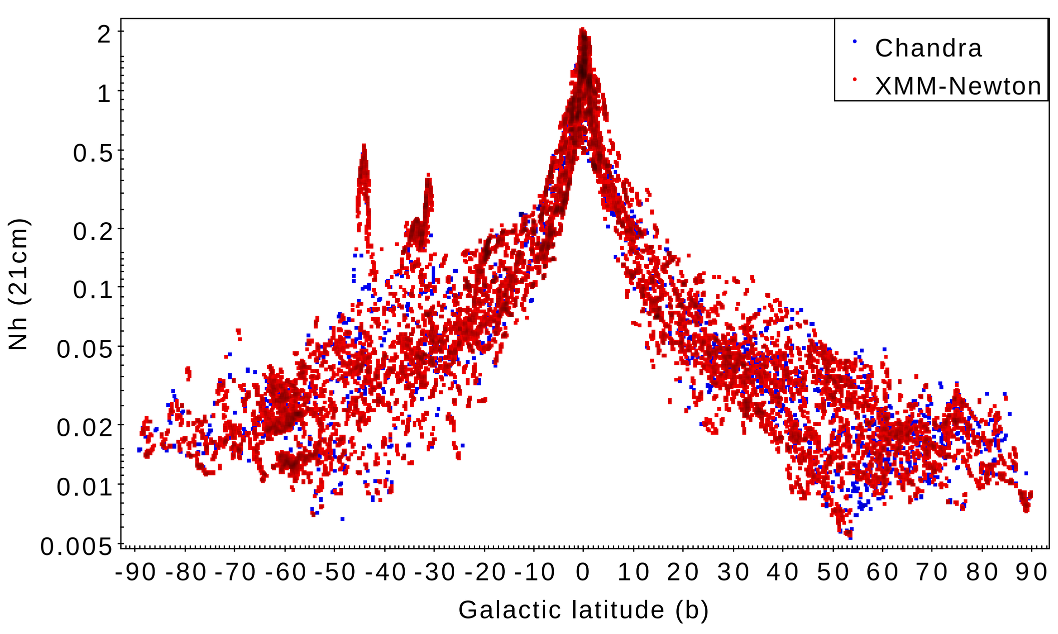
3D MAPPING OF THE NEUTRAL X-RAY ABSORPTION IN THE ISM

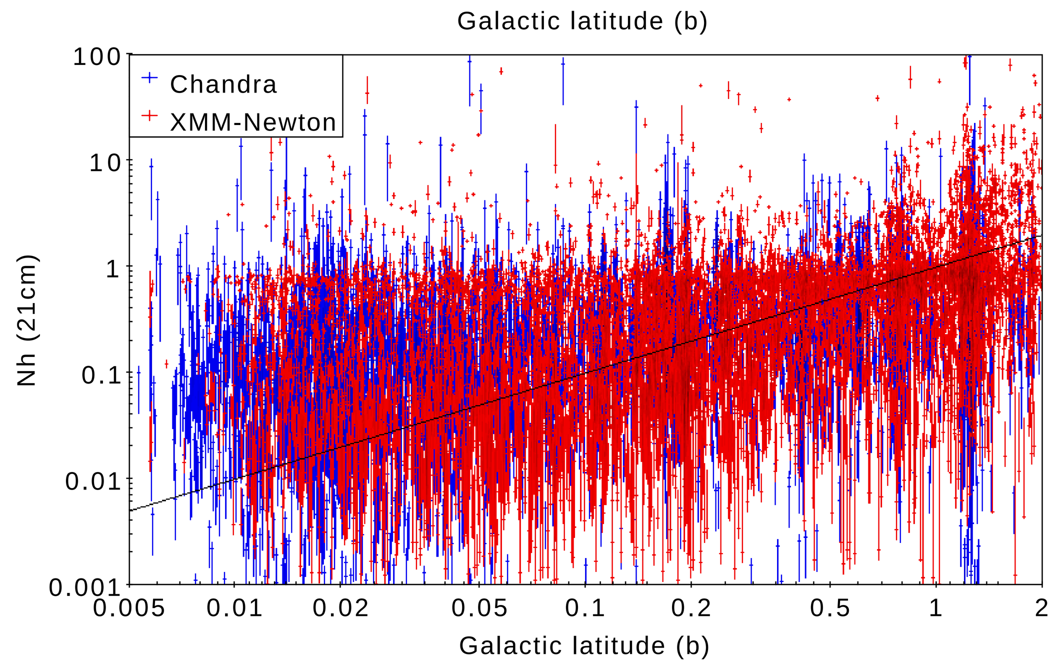
The gas distribution in the ISM, using the Nh column densities obtained from the fits, can be modelled according to the integral:

$$N_i = \int_o^s n_i(r)\,dr$$

Where *r* is the distance along the i l.o.s between the observer (*o*) and the source (*s*) and *ni(r)* is the density profile. We will use the method explained in Rezaei Kh. et al. (2017) and Gatuzz et al. (2018), to infer Hydrogen densities. The method uses a Bayesian approach to predict the most probable distribution of the density at any arbitrary point, even for line of sights along which there are no initial observations.







Left top panel: distribution of Nh for the best-fit models as function of the number of counts in the 0.5-10 keV keV energy regions.

Left bottom panel: Distribution of Nh for the best-fit models as function of the 21 cm measurements. The solid black line indicates the case when Nh(fits)=Nh(21cm).

Right top panel: distribution of Nh(21cm) measurements.

REFERENCES

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