NuSTAR discovers a cyclotron line and reveals the spinning up of the accreting X-ray pulsar IGR J16393−4643

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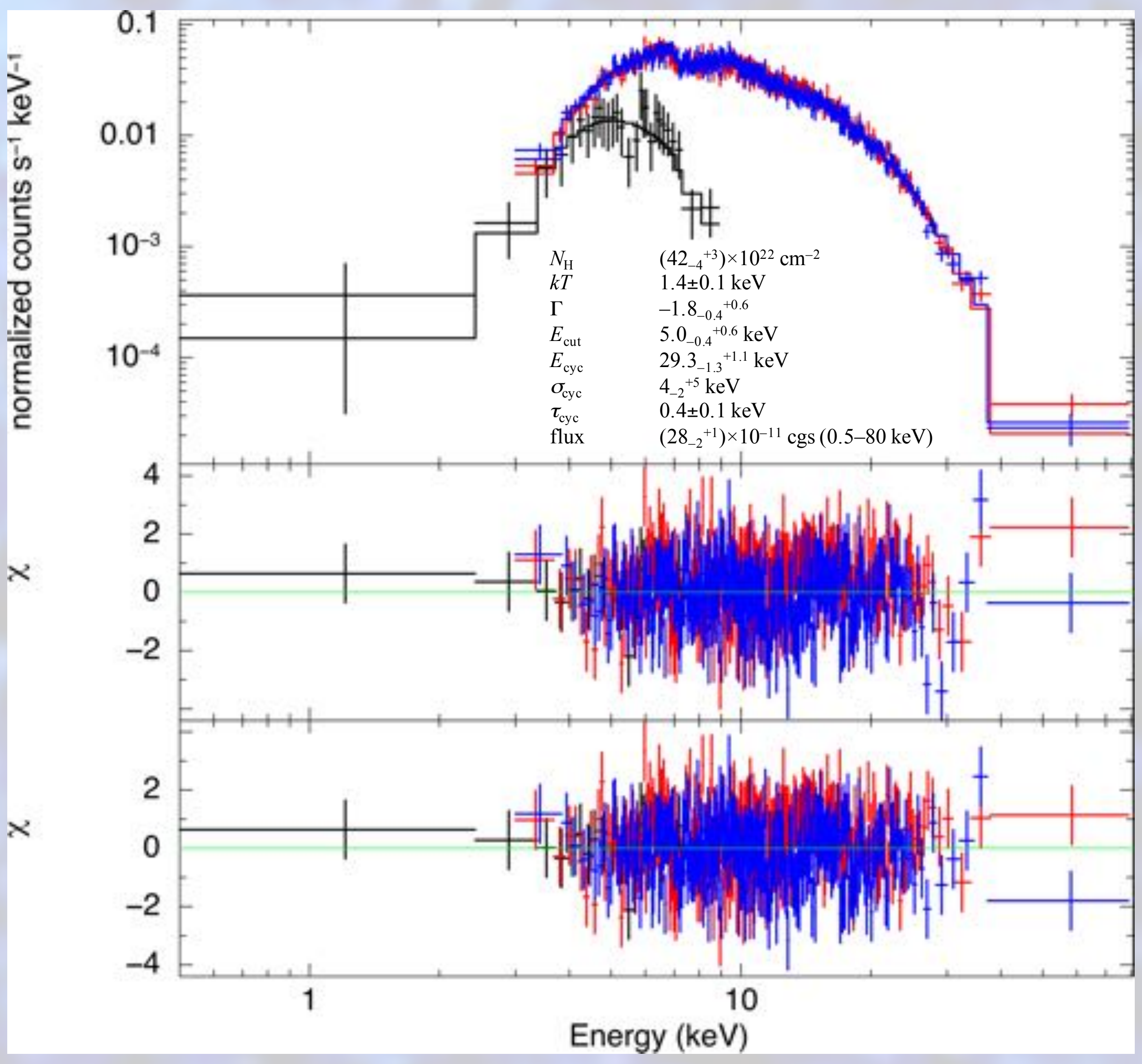
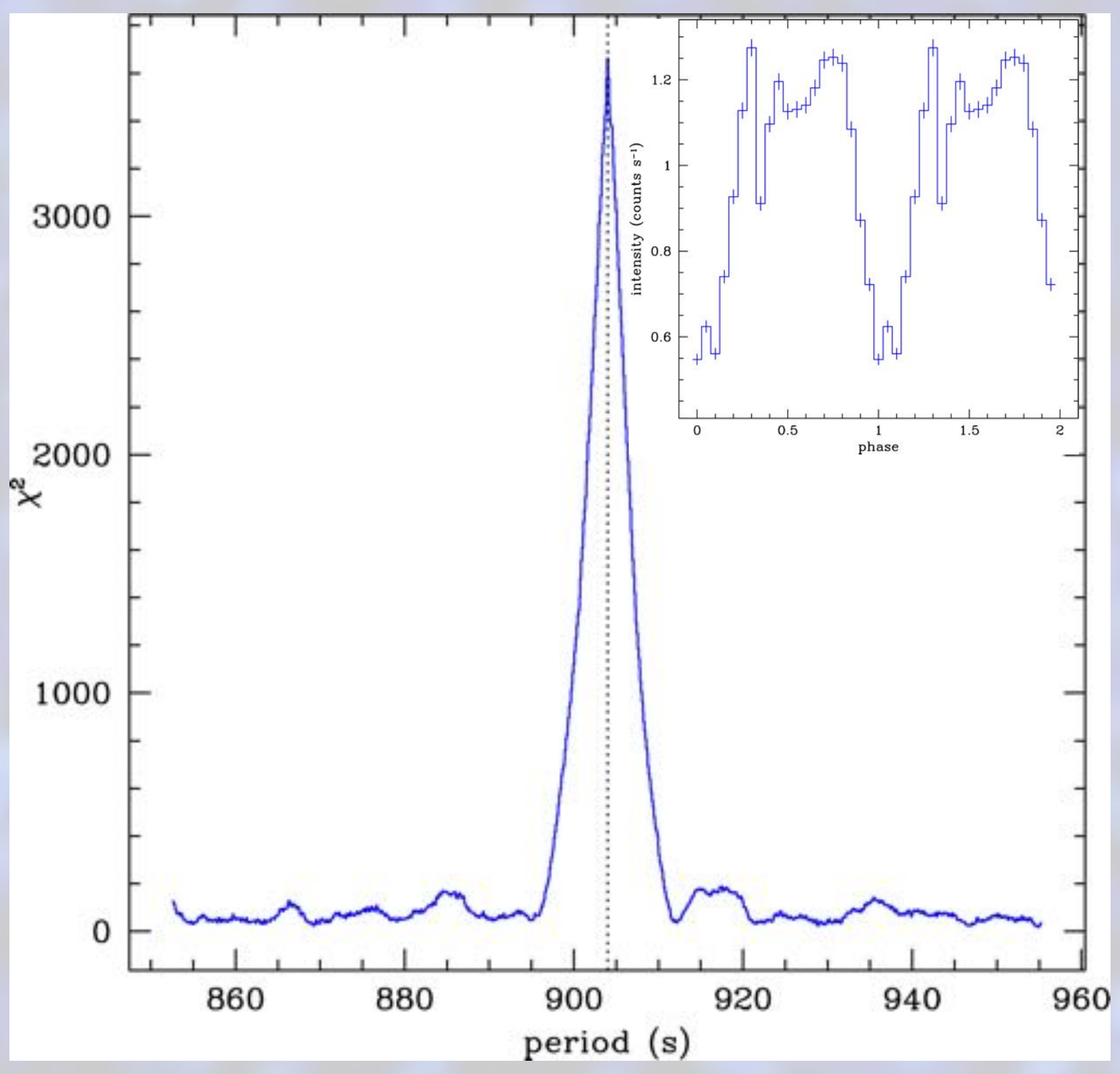
The high-mass X-ray binary and accreting X-ray pulsar IGR J16393−4643 was observed by *NuSTAR* in the 3–79 keV energy band for a net exposure time of 50 ks. This observation enabled the discovery of a cyclotron resonant scattering feature with a centroid energy of $29.3_{-1.3}^{+1.1}$ keV. This allowed the magnetic field strength of the neutron star to be measured for the first time: $B = (2.5\pm0.1)\times10^{12}$ G. The known pulsation period is now observed at 904.0±0.1 s. Since 2006, the neutron star has undergone a long- term spin-up trend at a rate of $P' = -2\times10^{-8}$ s s^{-1} (i.e., −0.6 s per year, or a frequency derivative of $\nu' = 3\times10^{-14}$ Hz s^{-1}). In the power density spectrum, a break appears at the pulse frequency which separates the zero slope at low frequency from the steeper slope at high frequency. This addition of angular momentum to the neutron star could be due to the accretion of a quasi-spherical wind, or it could be caused by the transient appearance of a prograde accretion disk that is nearly in corotation with the neutron star whose magnetospheric radius is around 2×10^6 m.



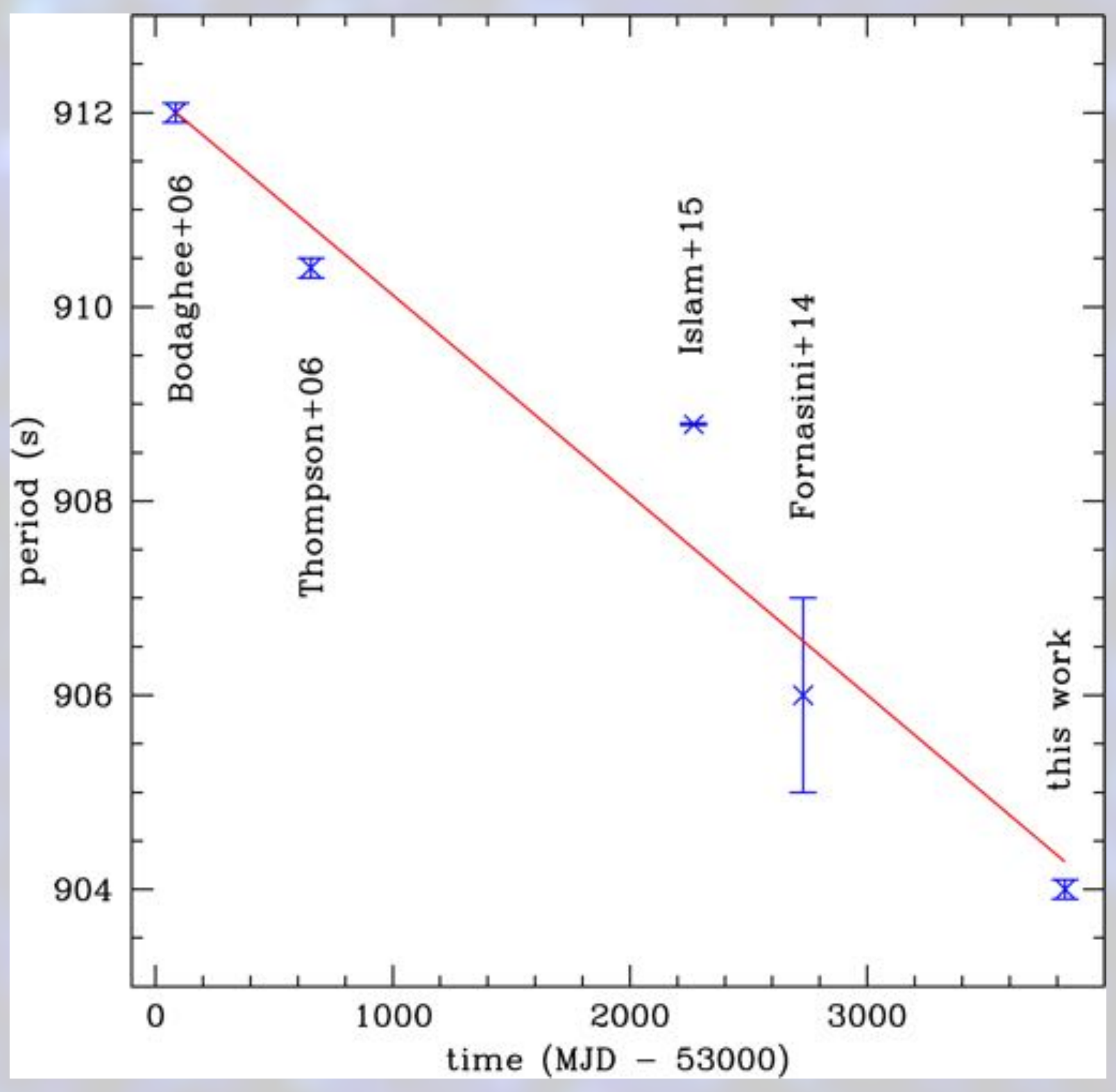
Background-subtracted spectra collected with *Swift*-XRT (black), *NuSTAR*-FPMA (blue), and *NuSTAR*-FPMB (red). Spectral bins for *Swift* contain a minimum of 5 source counts, while those of *NuSTAR* have a minimum significance of 7σ. The spectra were fit with a model consisting of an absorbed cutoff power law with a radial blackbody. The middle panel shows residuals from this model fit, while the bottom panel shows residuals when the model includes a cyclotron component. Error bars denote 90%-confidence limits. Simulations show that the cyclotron component significantly improves the fit (4.3σ significance accounting for trials).

Given a centroid energy of $29.3_{-1.3}^{+1.1}$ keV for the cyclotron line, the magnetic field strength of the neutron star can be measured for the first time: $B = (2.5\pm0.1)\times10^{12}$ G.



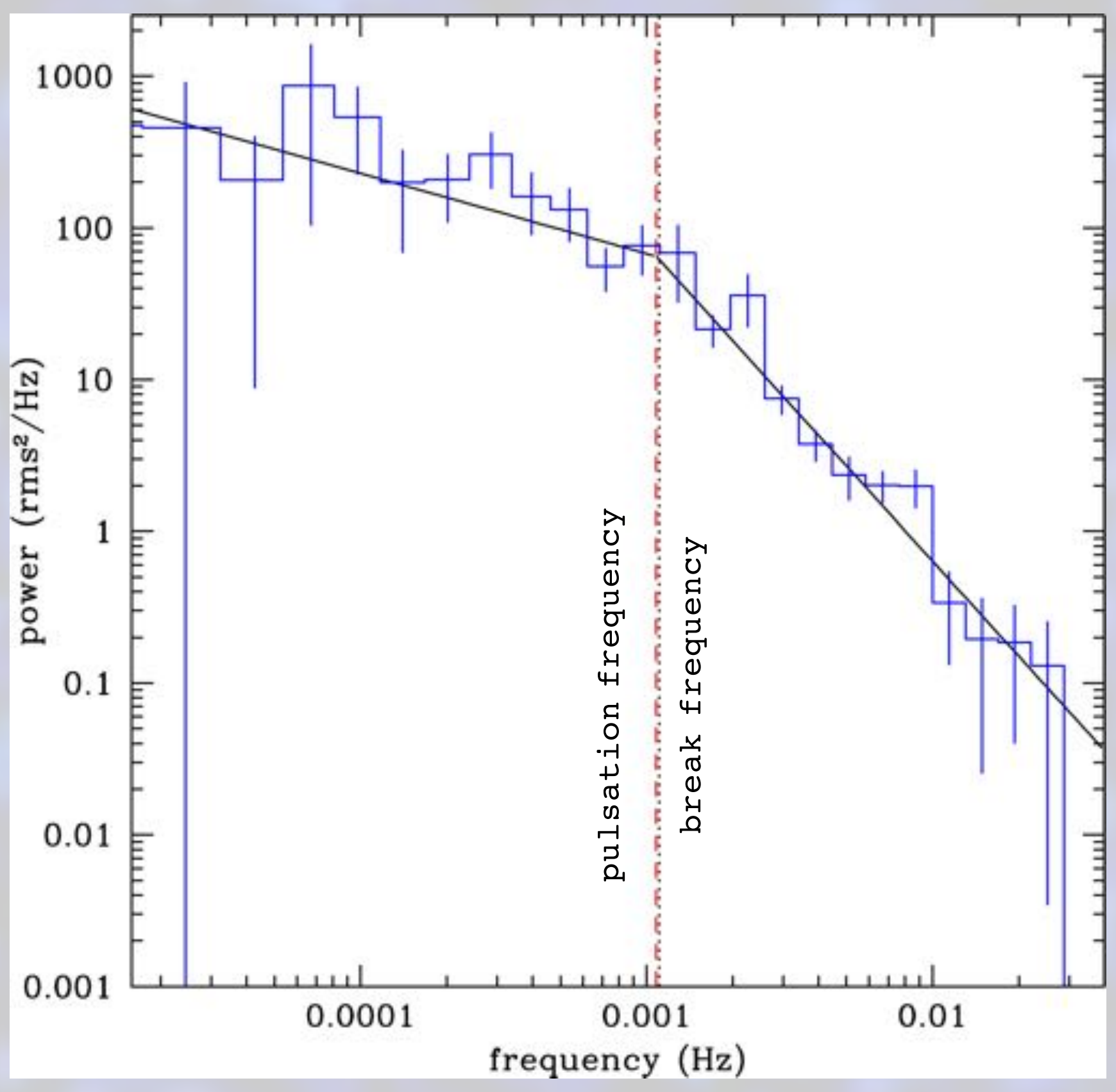
Periodicity search (χ^2 distribution) for the *NuSTAR* light curve (3–79 keV) with 20 bins per pulse period, and a resolution of 0.1 s. The known pulsation period is now detected at 904.0±0.1 s (vertical line). The inset shows two phases of the pulse period in the 3–79 keV energy band beginning at MJD 56834.209667(1).

The spin period has evolved since its discovery.



Evolution of the pulsation period as reported in the literature. Since 2006, the neutron star has undergone a long-term spin-up trend at a rate of $P' = -2\times10^{-8}$ s s^{-1} (i.e., −0.6 s per year, or a frequency derivative of $\nu' = 3\times10^{-14}$ Hz s^{-1}).

Angular momentum has been transported to the neutron star via a quasi-spherical wind or a transient prograde accretion disk.



Power density spectrum (rms-normalized) after subtraction of both the average pulsed periodic component and the expected level of white noise. A break is required in the power law model in order to adequately fit the data (solid lines). The dashed vertical line indicates the pulsation frequency while the dotted vertical line denotes the break frequency.

This suggests a truncated accretion disk that is nearly in corotation with the neutron star whose magnetospheric radius is around 2×10^6 m.

Bodaghee et al., 2016, ApJ accepted, arXiv:1603.05580