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Long-term evolution of the neutron star magnetic field in Her X-1 indicated by the decay of the cyclotron line energy

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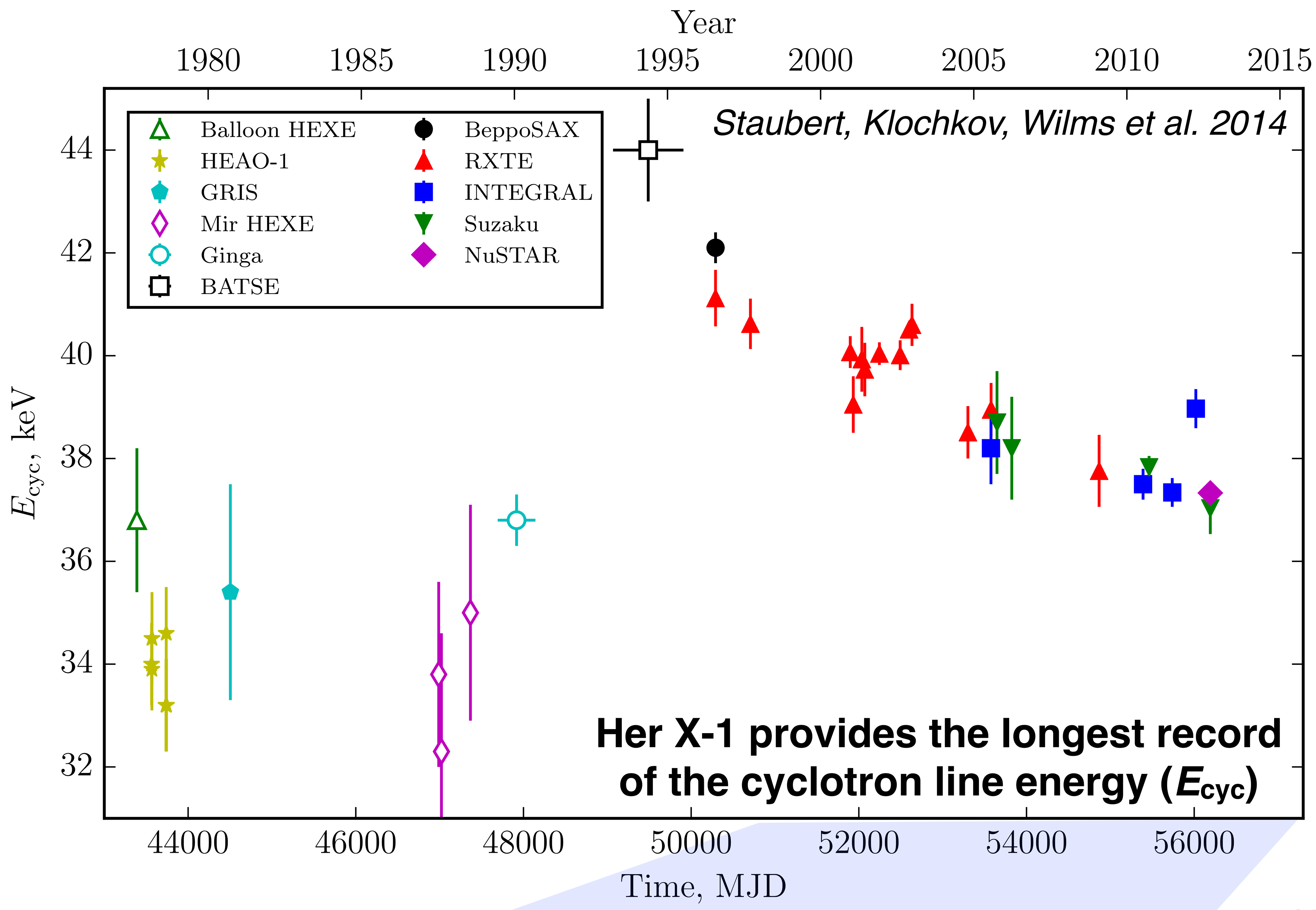
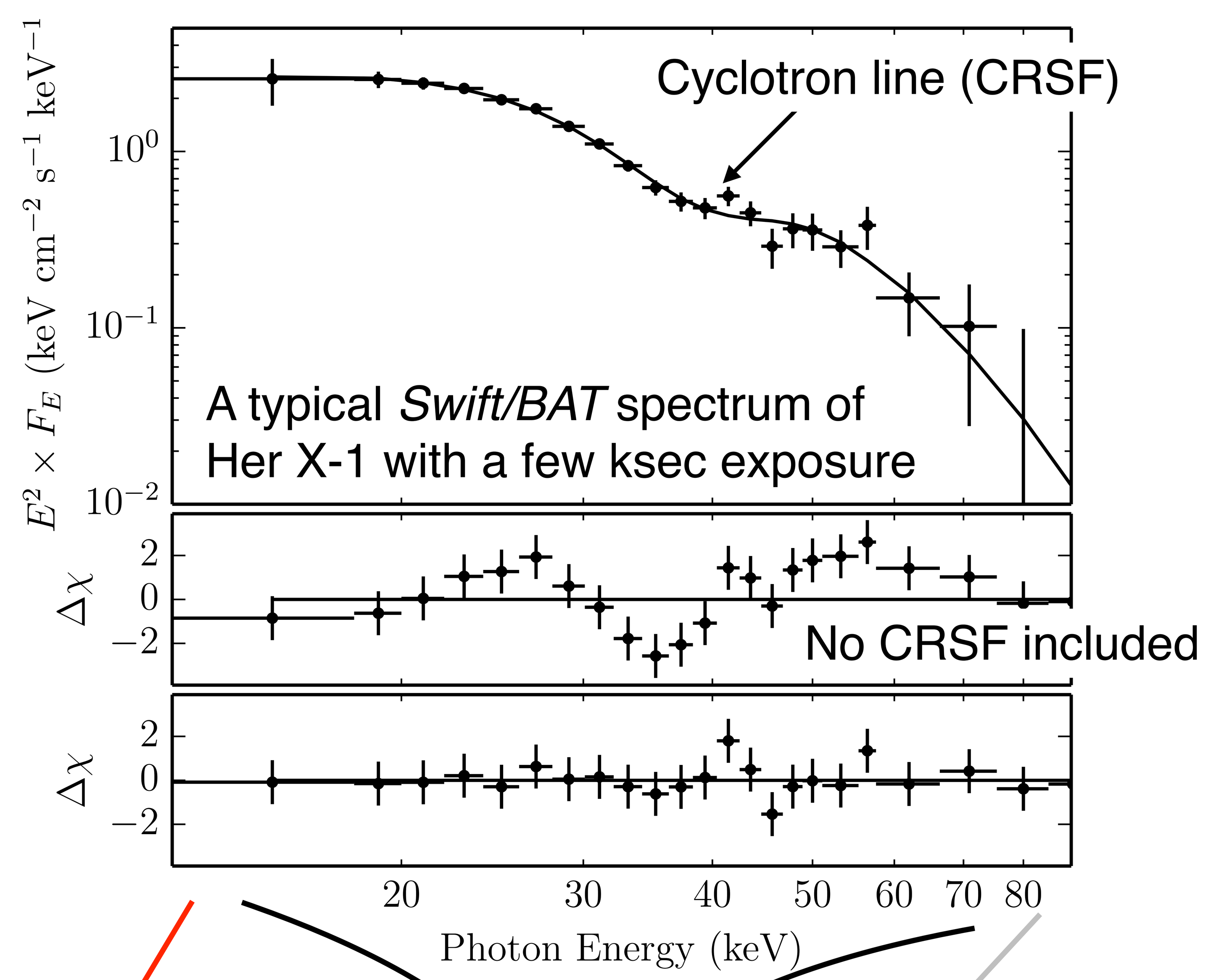
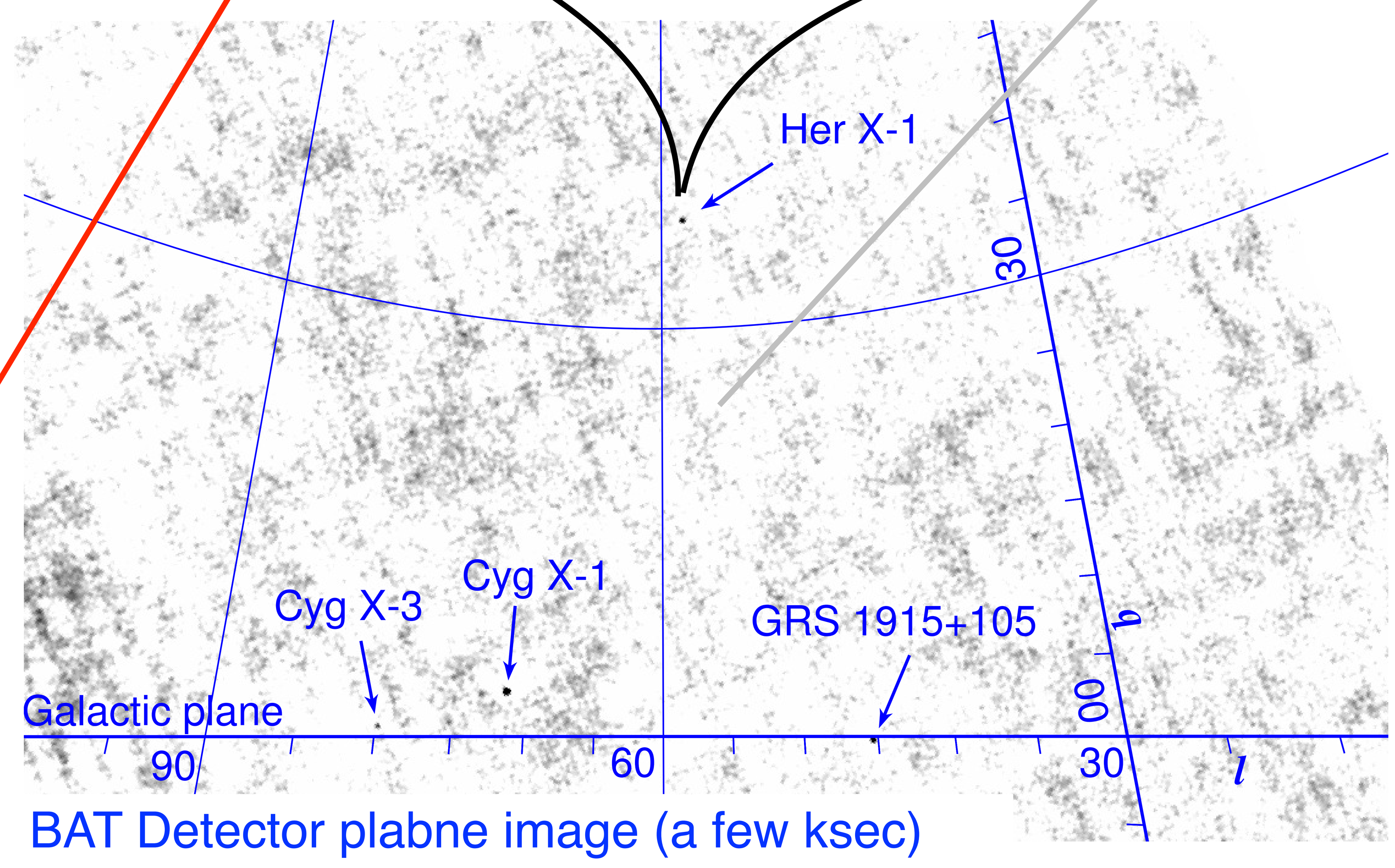


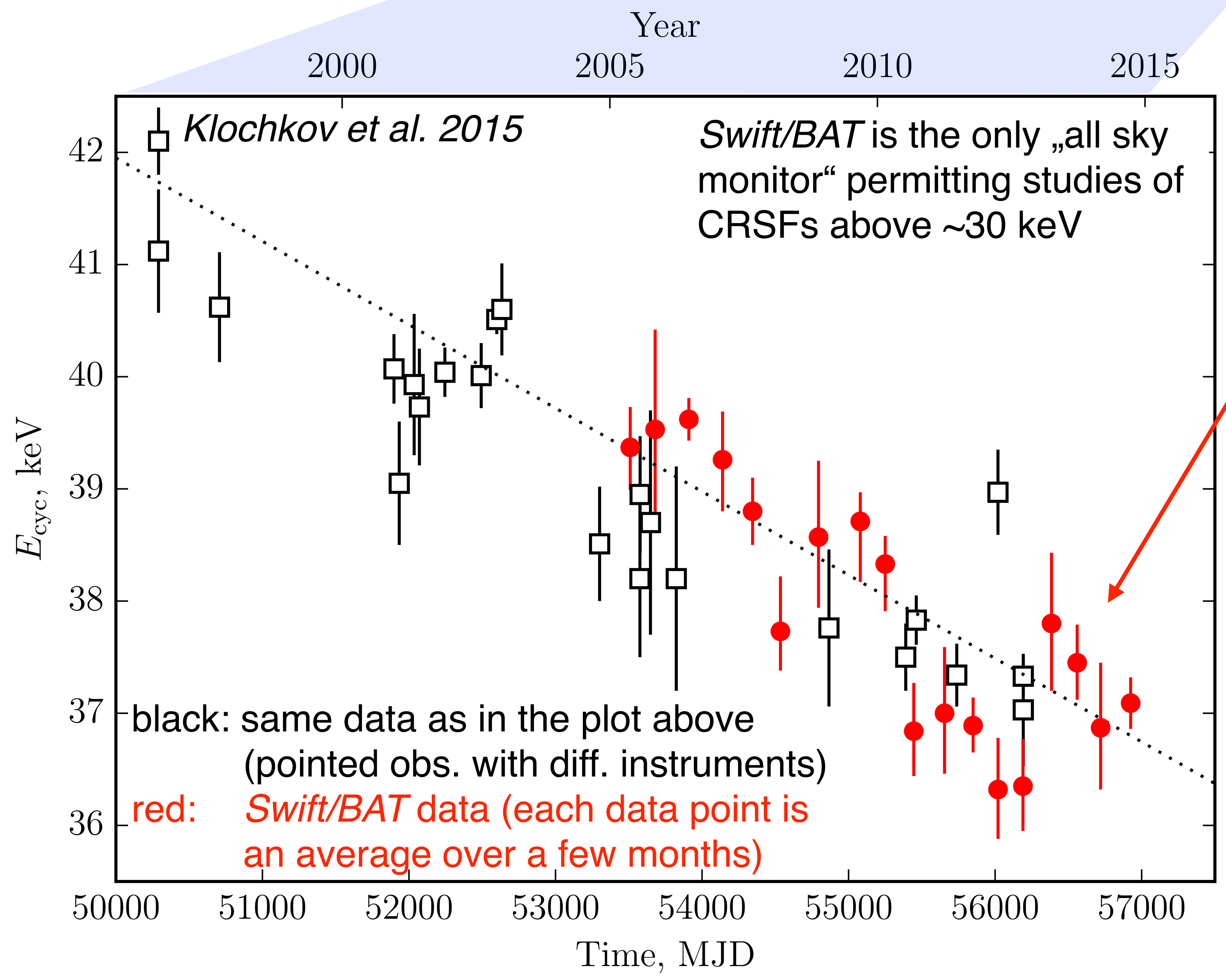
Her X-1 provides the longest record of the cyclotron line energy (E_{cyc})

Swift/BAT provides a quasi-continuous monitoring of E_{cyc} in Her X-1. Individual data points are the result of measurements averaged over several months. Short-term L_X- and E_{cyc}-variations **are averaged out.**





BAT Detector plabne image (a few ksec)

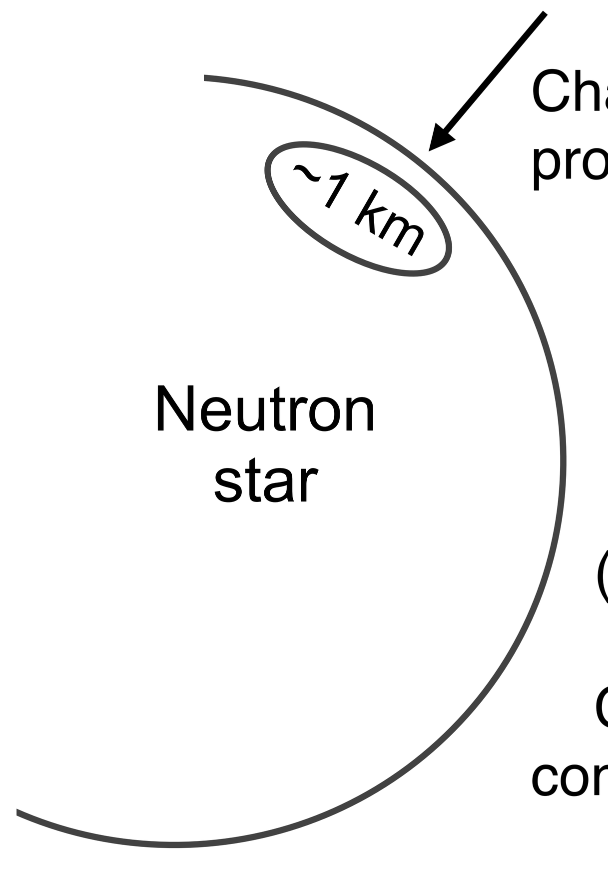


***Swift/BAT* (red data points) confirms the long term decay of the CRSF energy after ~2005.** The *BAT* measurements alone indicate dE_{cyc}/dt = -0.32(3) keV/year, which is consistent (within ~2σ) with the values -0.26(1) and -0.28(1) keV/yr reported in *Staubert, Klochkov et al. (2014)* for the pointed observations with and without taking the $E_{cyc} - L_X$ dependence into account, respectively. The significance of the negative E_{cyc}—time correlation is characterised by the two-sided *P*-value (null hypothesis probability) of ~10^{-5}.

The observed timescale of the decay is very short:

$$(-E_{cyc}/\dot{E}_{cyc}) \sim 100\,\mathrm{yr}$$

The E_{cyc} decay must represent **local** variations of the *B*-field at the emitting polar caps with a size of ~1 km



Characteristic timescales of different physical processes for R_{pol}~1 km:

$\tau_{Ohmic} \sim 4\pi R^2\sigma/c^2 \sim 10^2$ yr - works well!

$\tau_{Hall} \sim 5 \times 10^8 (R_5^2/B_{12})(\rho/\rho_{nuc})$ yr ~10^5 yr - too long!

Time for accumulation of M_{crit} ~10^{-5} $M_\odot$ (*Payne&Melatos 2004*): ~10^4 yr - too long!

Characteristic time of a local *B*-field evolution computed by *Priymak et al. (2014)*: ~100-1000 yr - might work!

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