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A Precessing Jet in Sw J1644+57

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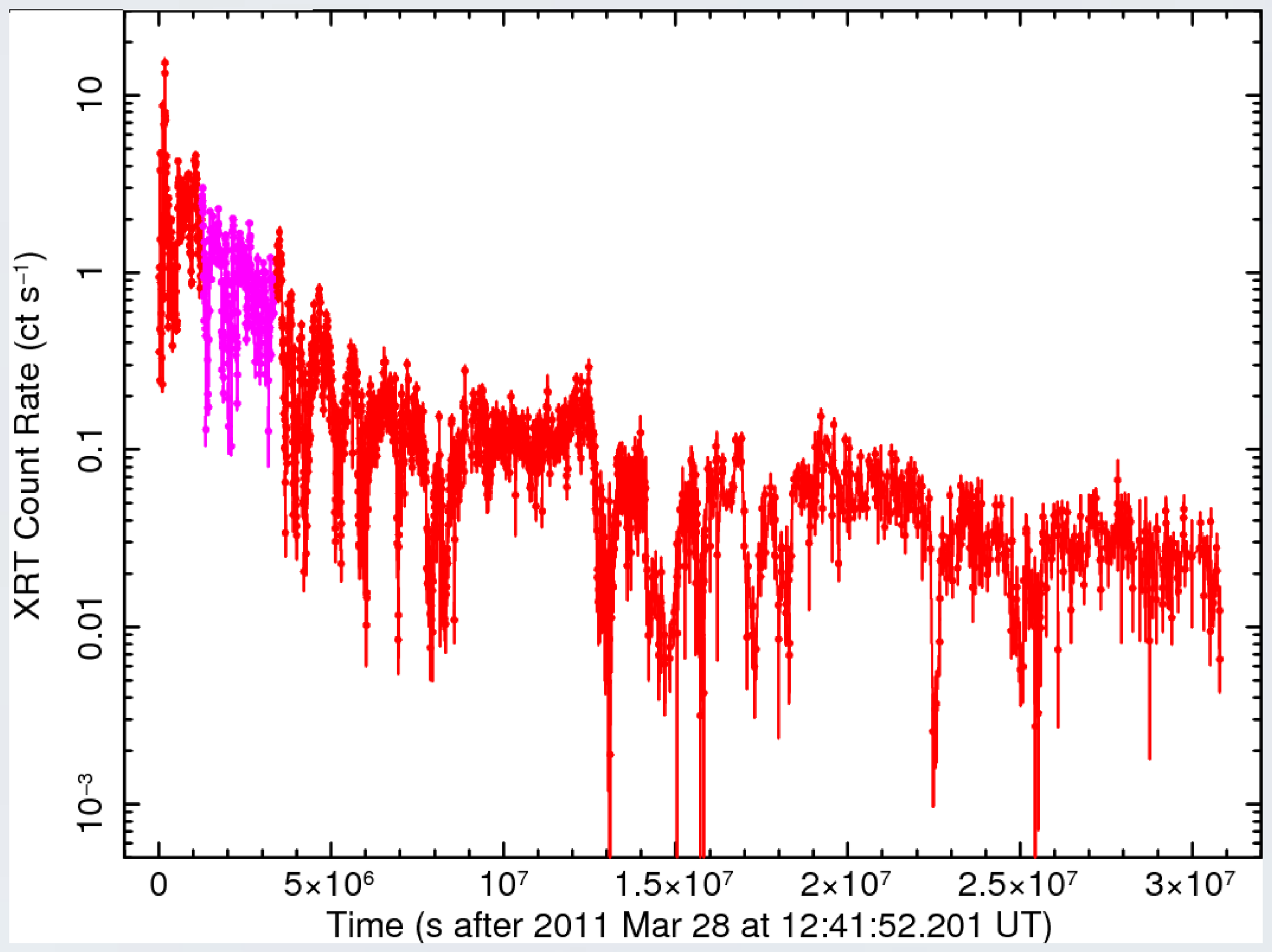
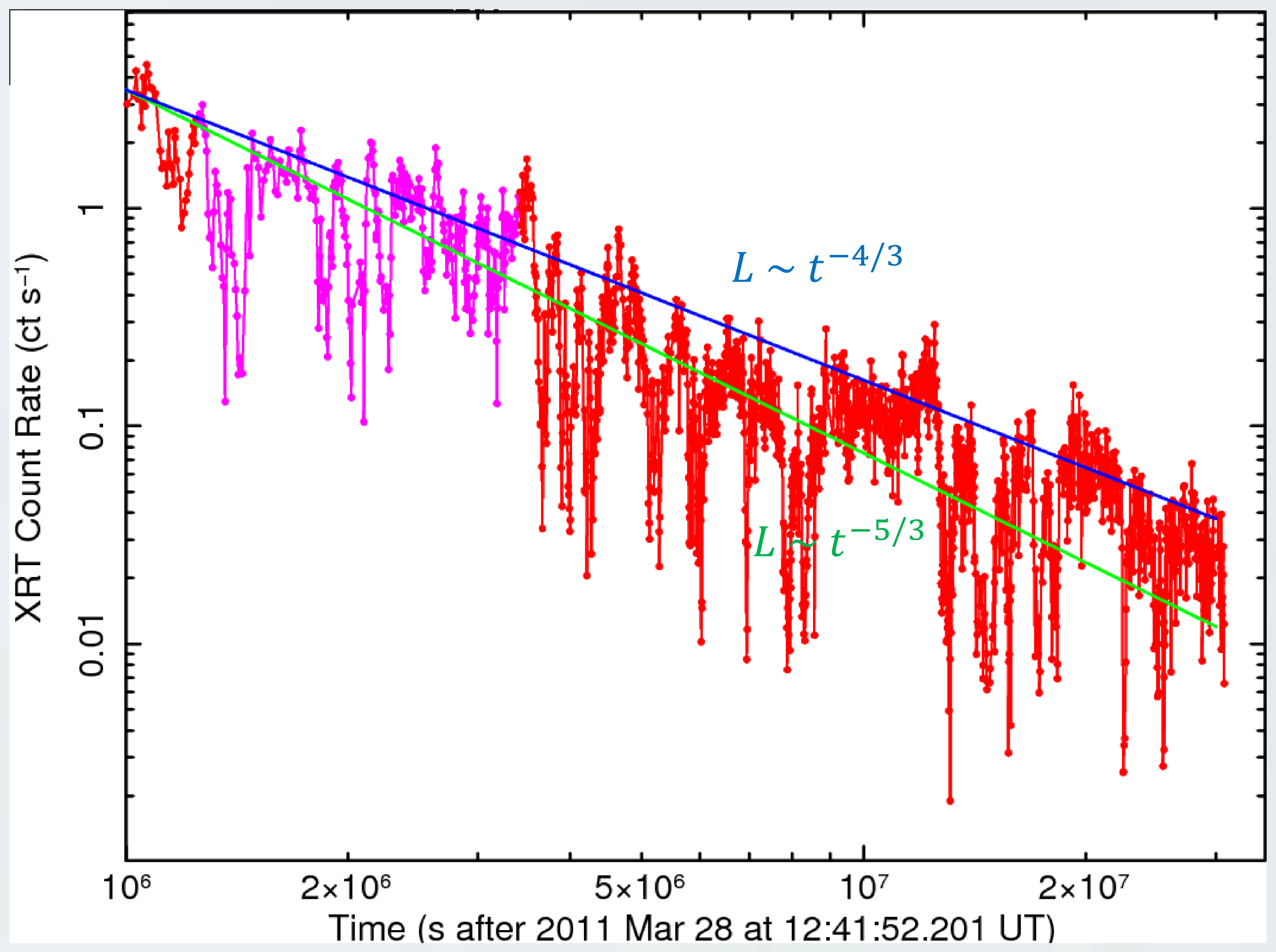
1 year lightcurve: slow decline and dips

Exactly 1 year on from its outburst, the transient blazar-like source Sw J1644+57 (Burrows et al 2011; Bloom et al 2011; Levan et al 2011), located in the nucleus of a galaxy at z = 0.35, continues its X-ray decline. Its X-ray lightcurve shows a slowly declining baseline flux level, interrupted by recurrent sharp dips. After each dip, the flux returns to the baseline level before the dip.



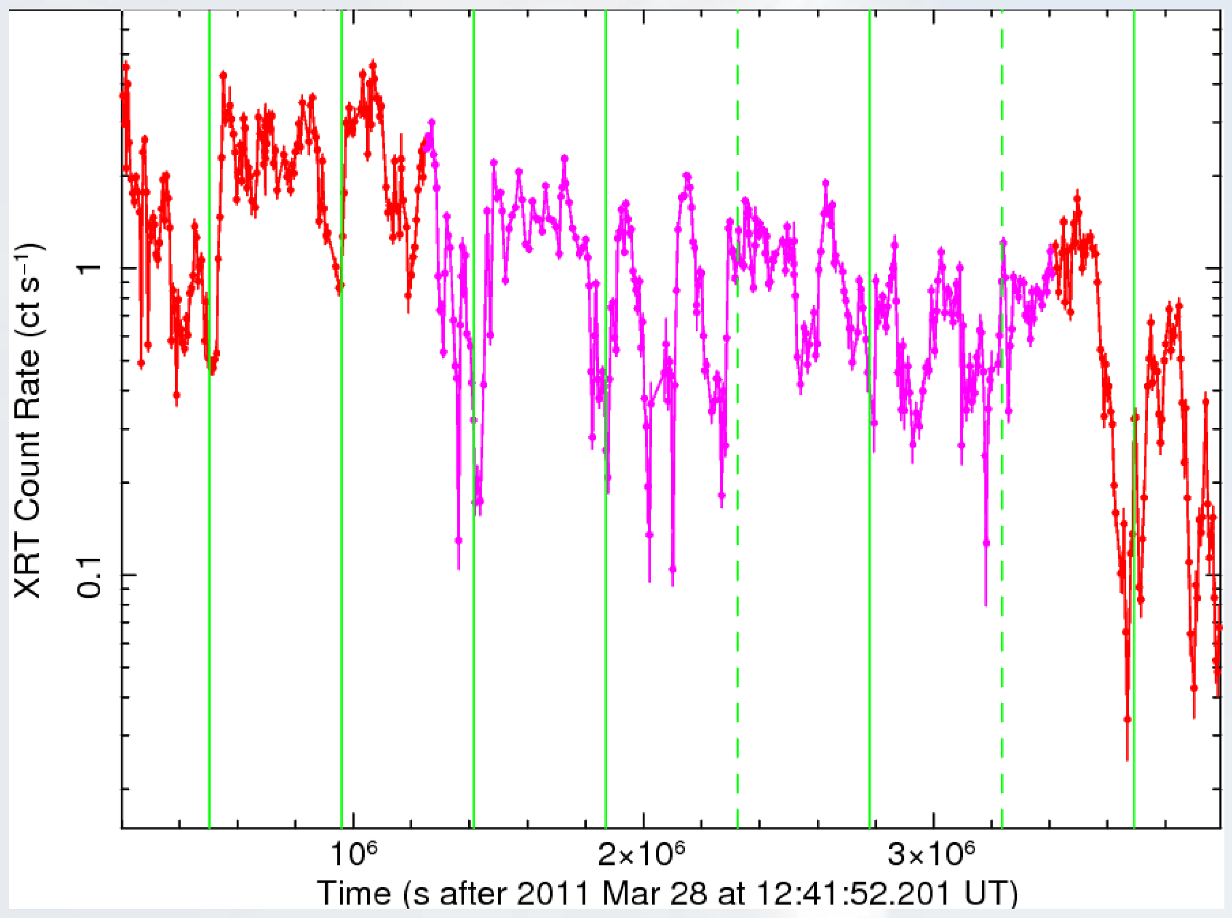
When fitted with a single power law, the long-term decline scales as t^(-4/3), flatter than the asymptotic slope t^(-5/3) predicted for tidal debris accretion. However, we find an equally good fit with a double exponential model, with an e-folding timescale ~ 2E6 s until a time t ~ 8E6 s ~ 3 months after the burst, and an e-folding timescale ~ 1.1E7 s after that. The characteristic interval between dips, and the duration of each dip, are increasing with time.



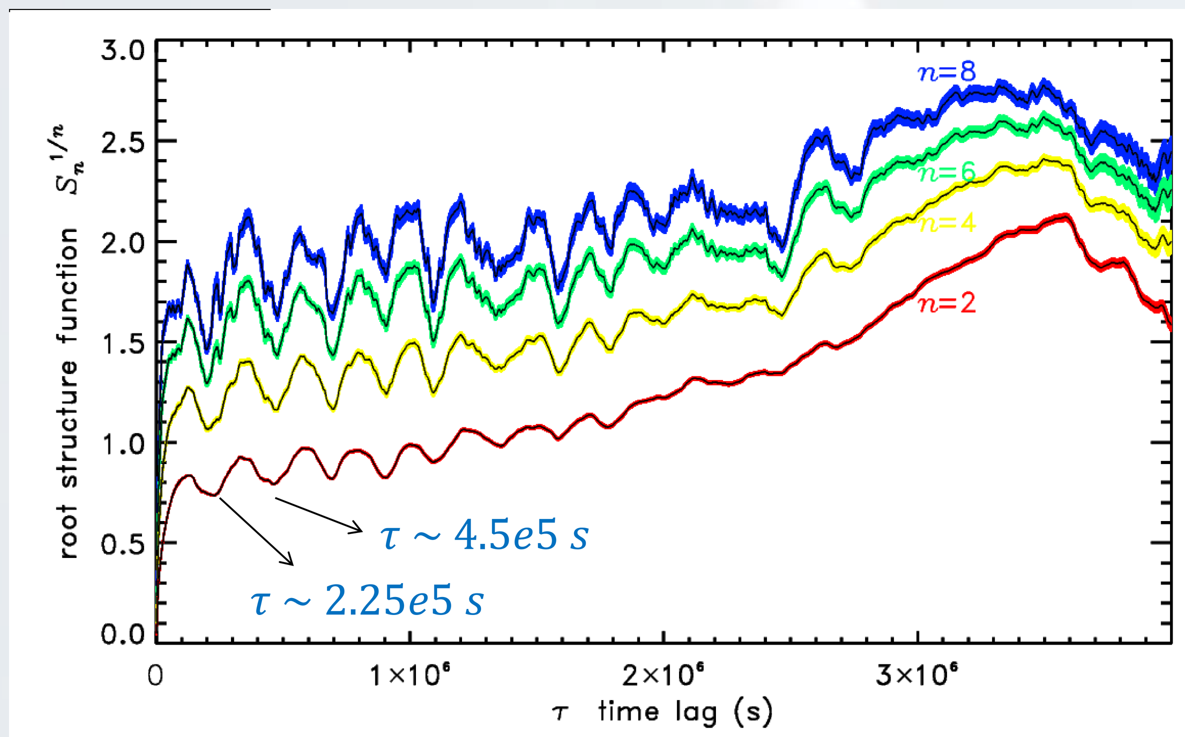
We studied the dipping behaviour, looking for periodicities. Simple analysis of its power density-spectrum is inconclusive. So, we used more powerful statistical techniques: Lomb-Scargle periodograms and structure function analysis (Saxton et al 2012).

Characteristic dipping timescales

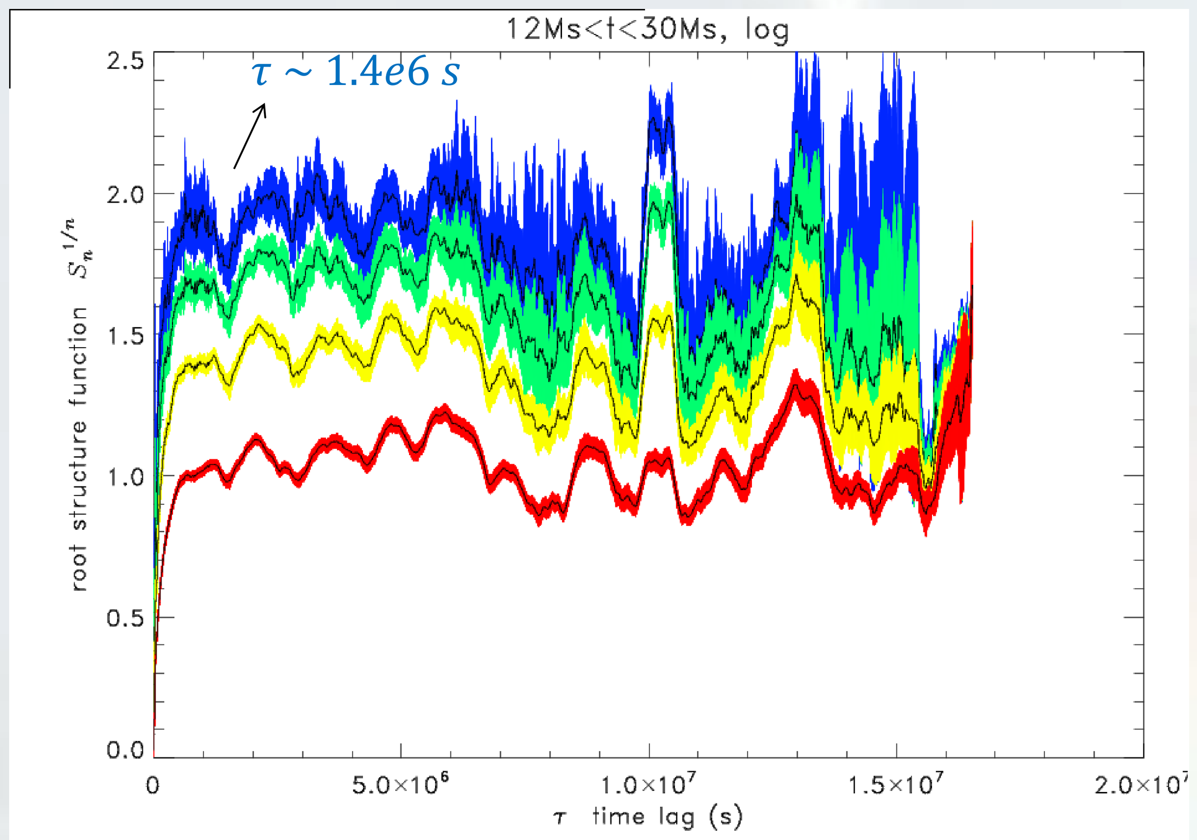
We found that the dips are not random but occur preferentially at time intervals ~ [2.3, 4.5, 9] x 10^5 s and their higher-order multiples, during the first few weeks after the burst. At later epochs, dipping resumed at ~ [0.7, 1.4] x 10^6 s.



A characteristic (but not exactly periodic) dipping interval ~ 4.5 x 10^5 s is visible by eye in the first few weeks (plotted above), and is confirmed as a local minimum in the structure functions at all orders (plotted below). Several higher harmonics are also significantly detected.



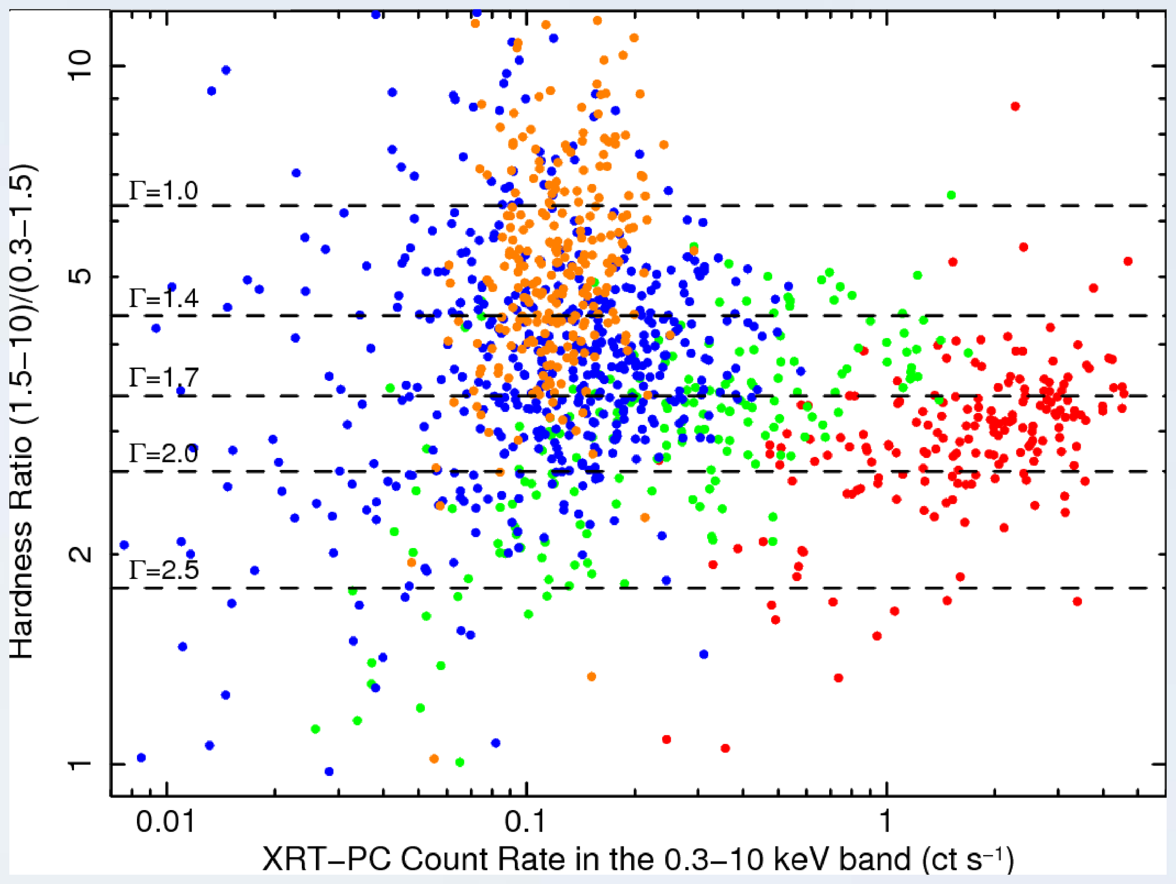
At later epochs, the dominant timescales are 1.4 x 10^6 s and at least 7 of their multiples (plotted below).



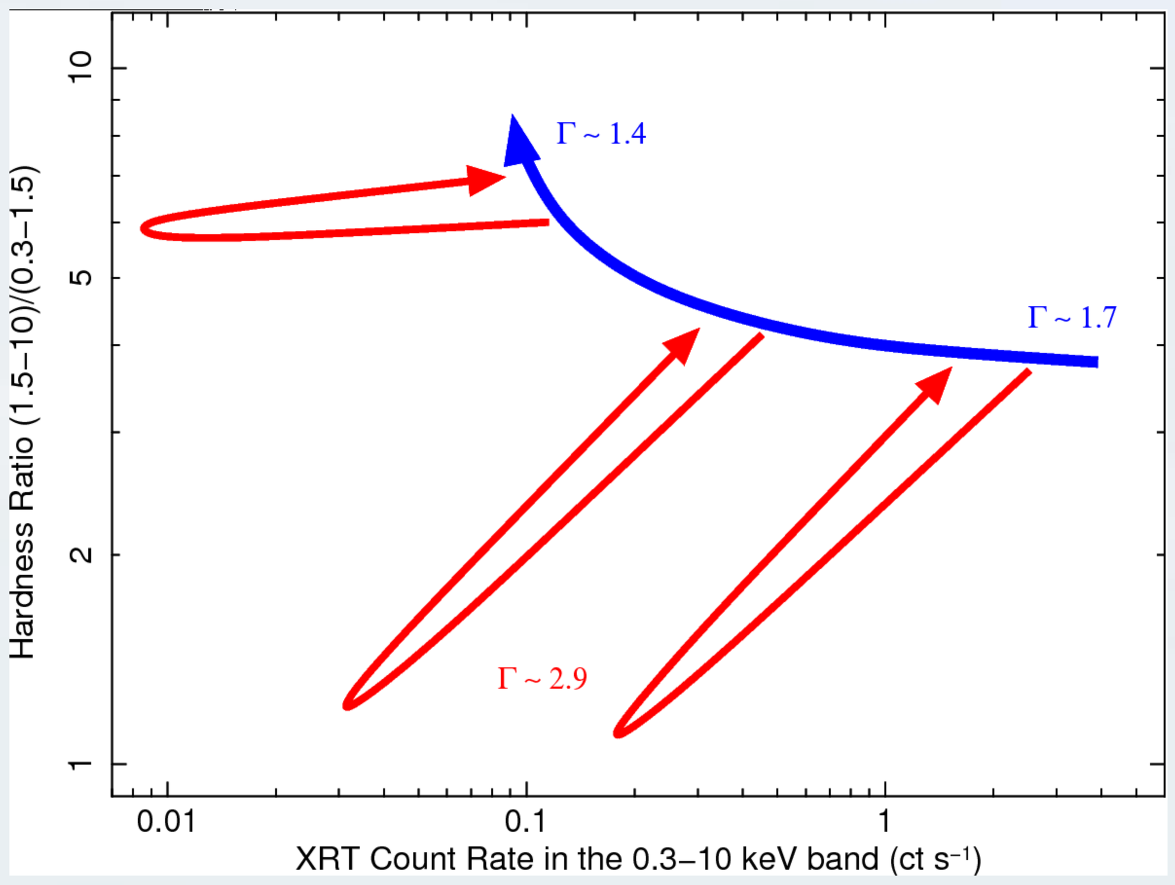
Interpretation of the dips: jet precession

From our time-resolved X-ray spectral and colour analysis, we found (Saxton et al 2012) that:

a) The baseline spectrum is a (synchrotron?) power-law. No lines or breaks or thermal components.
b) The baseline power-law gets moderately harder during the decline, from a photon index ~ 1.8 to ~ 1.4.
c) The X-ray spectrum gets much softer during each dip, steepening to a photon index ~ 2.5-2.9
d) The neutral hydrogen column density seen during the dips and outside remains the same.



In the hardness-flux diagram above, datapoints in red, green, blue and orange represent 4 successive epochs. The sketch below is a schematic interpretation of the hardness – colour evolution with a slow decline and dips.



We propose that the jet in SwJ1644 undergoes precession and nutation, which causes the collimated core briefly to go out of our line of sight. The X-ray flux in the dips comes from an envelope of less collimated, less energetic electrons around the core. The characteristic dip frequencies may correspond to the Lense-Thirring precession of a warped disk (see also Lei, Zhang & Gao 2012). The observed increase in the dip frequencies may be explained by a disk warp radius propagating outwards.

More details in Saxton, Soria, Wu & Kuin 2012, MNRAS, in press (arXiv:1201.5210)

Other references:
Bloom et al 2011, Science, 333, 203 --- Burrows et al 2011, Nature, 476, 421 --- Lei et al 2012, arXiv:1202.4231 --- Levan et al 2011, Science, 333, 199

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