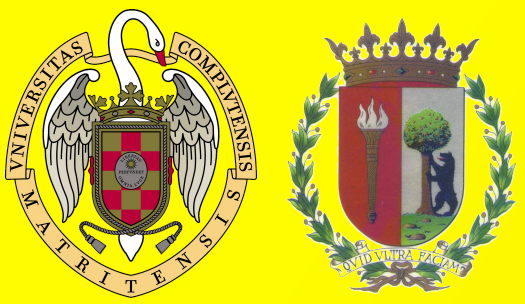


COMPARATIVE ANALYSIS OF MULTIPLE OUTBURSTS IN THE Be X-RAY BINARY 4U0115+63



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ABSTRACT

Be X-Ray binaries, as accretion-powered pulsars, constitute a unique laboratory for the physics of accretion column and its interaction with strong magnetic fields. They exhibit giant outbursts, as well as normal outbursts, reaching a very high luminosity and being among the most luminous objects in the X-ray sky during these active states. In spite of this fact and even though they are the most common type of high-mass X-ray binaries, Be X-ray binaries have not been as thoroughly studied as low-mass X-ray binaries (LMXRB). Nevertheless, recently there have been first attempts to apply some of the concepts that have been proved

to be successful in LMXRB studies to high-mass X-ray binaries such as the definition of "sources states".

Our goal is to do a full comparative study of three major outbursts of the well-known Be X-ray binary 4U 0115+63 as observed with the RXTE satellite. While individual results have been published for these outbursts, a systematic comparison is lacking so far and the main goal of the study. We present X-ray spectroscopy and colour analysis as some preliminary results of the project, still in progress.

THE SOURCE 4U 0115+63

4U0115+63 is one of the best studied transients in the X-ray sky. Since it was first detected in 1974, it has been a frequent target for space X-ray observatories as well as for optical ground-based telescopes. The source is a High Mass X-Ray Binary, consisting in a neutron star and a B0.2e or a heavily reddened O9e fast-rotating dwarf companion identified as V635 Cas. An equatorial disc around the companion is thought to be responsible for the emission line formation and the observed infrared excess, but the mechanisms of formation, dissipation or disruption and its influence in variability or rotation rate remain as open questions under the so-called "Be Phenomenon".

The orbital parameters have been studied in great detail. It may be expected for this source, given the low eccentricity ($e = 0.34$), that a large gap between the equatorial disc outer edge and the Lobe radius of the optical star would prevent the neutron star from accreting enough matter at the periastron passage to undergo quasi-periodic normal outbursts. For 4U0115+63, giant outbursts are more common than normal ones and they seem to be modulated by a 3 - 5 years period. During the giant outburst the X-ray luminosity exceeds 10^{37} erg/s.

In addition, the exhibition of cyclotron resonant scattering features (CRSF) up to the fourth harmonic line makes this source a unique scenario to study the physics of the accretion column and the polar caps on the neutron star surface.

SPECTRAL ANALYSIS

We have extracted data from PCA and HEXTE instruments on board RXTE satellite using FTOOLS v6.11 and we have carried out spectral analysis observation by observation using XSPEC v12.7.0. *Standard-2* configuration was selected for PCA/PCU2, although datafiles in *Standard-1* configuration were also extracted in order to apply the dead-time correction. We extracted *Standard* datafiles using Cluster B on HEXTE for 2008 outburst.

We present spectral analysis only on the 2008 outburst, as a first result of a project still in progress. Once the spectra had been corrected and background-subtracted we fitted data from both instruments as one. We select bins in the 3-30keV energy range for PCA and 25-100keV for HEXTE. We modeled the spectral continuum using a power law with a high-energy cutoff (CUTOFFPL) and then we added several features:

- Photoelectric absorption (PHABS) with a frozen column density, $N_H = 1.55 \cdot 10^{22} \text{ cm}^{-2}$, corresponding to the mean value obtained from all best fits with free parameters.
- The Fe emission line (GAUSSIAN) with the line energy fixed at 6.49keV, again a mean value.
- The so-called "10-keV feature" (GAUSSIAN).
- Lorentzian profiles for cyclotron absorption features up to the second harmonic line (CYCLABS).

RESULTS AND DISCUSSION

We verify the expected behaviour of the photon index along the 2008 outburst. The source becomes harder near the flux peak and it is softer in the rise and decay phases. However, considering the source is above the supercritical luminosity during the outburst, the photon index is expected to anticorrelate with the luminosity, while our results show exactly the opposite trend.

Reig and Nespoli (2013) have proved this anticorrelation to be strong and significant for the 2004 outburst. Since the source displays different behaviours while reaching a similar peak luminosity, then one of the factors determining the critical luminosity must have changed if the model in Becker et al. (2012) applies, letting the source be in the subcritical regime in the 2008 outburst as the photon index would show. For instance, the Alfvén radius may be different and thus the polar cap size, as they are assumed to be coupled in the model, but it may not be the only modified parameter.

On the other hand, the hardness-intensity diagram would point that the source is supercritical at the peak of the outburst in 2008, as quite similar branches to those for the other outbursts are clearly depicted. Since the physics of the accretion column is not well understood yet, a full explanation of this apparent conflict is still an open question.

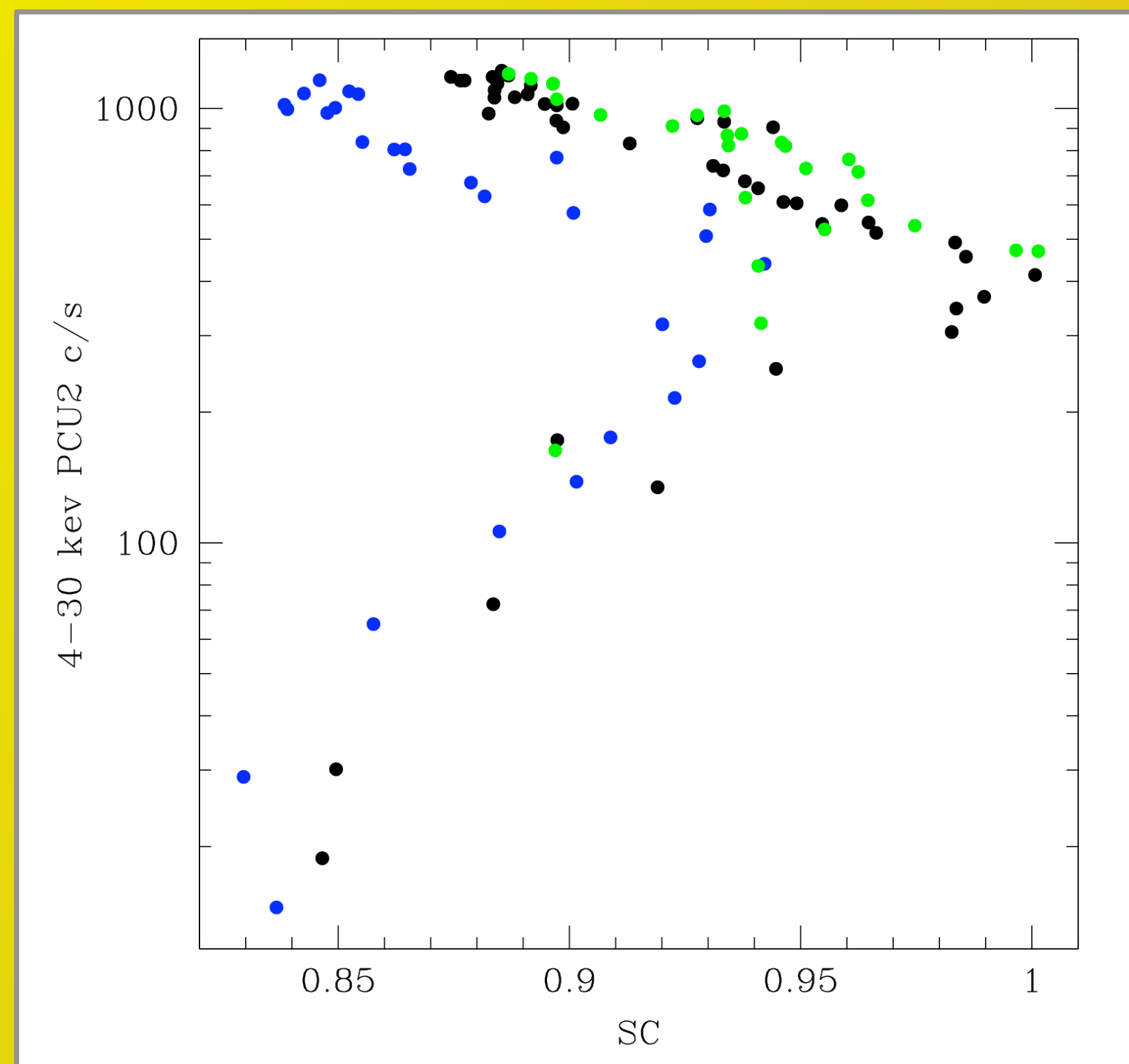


Figure 1 (top): Hardness-Intensity Diagram for the three outbursts. Soft colour is defined as the ratio of count rate in energy bands 7-10keV over 4-7keV. Figure 2 (bottom): Light curves for the three outbursts, representing count rates for PCA / PCU2 in the 3-30keV energy band.

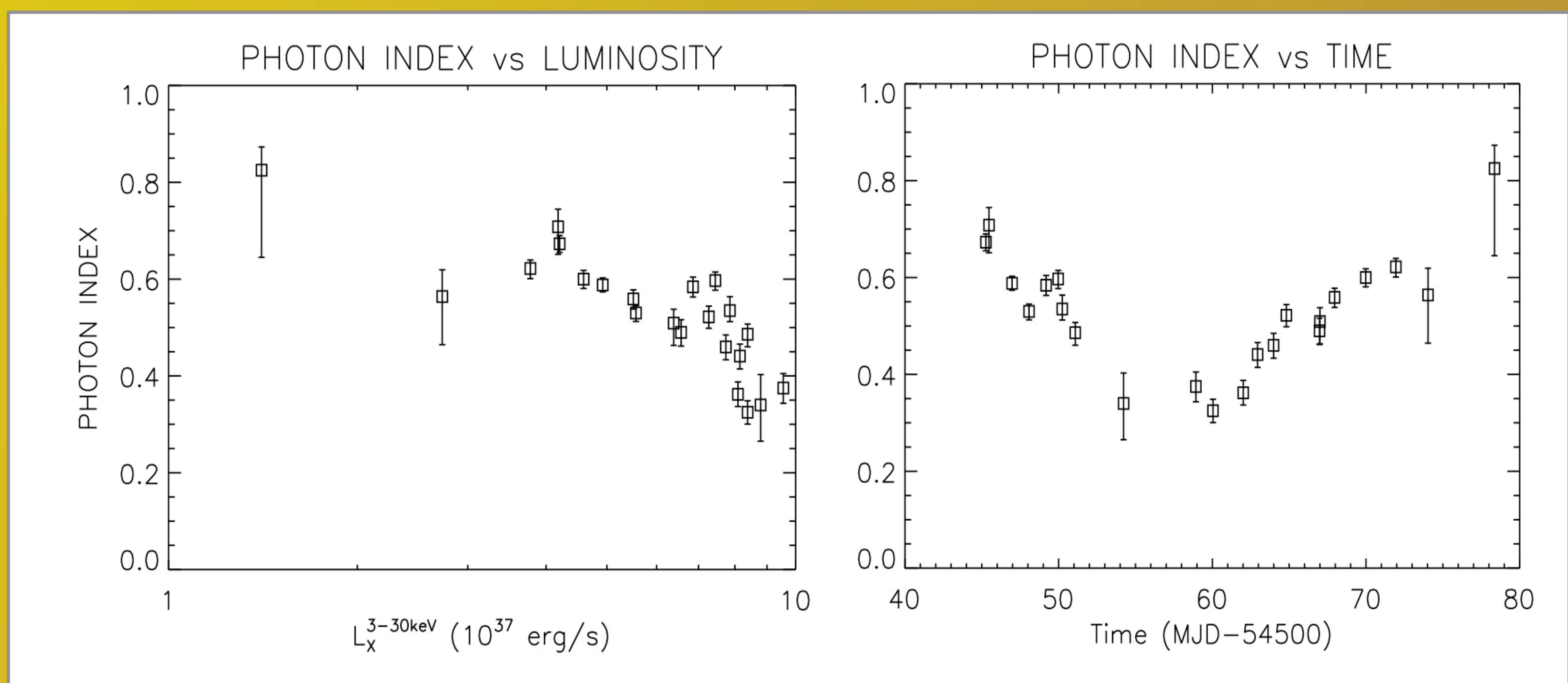
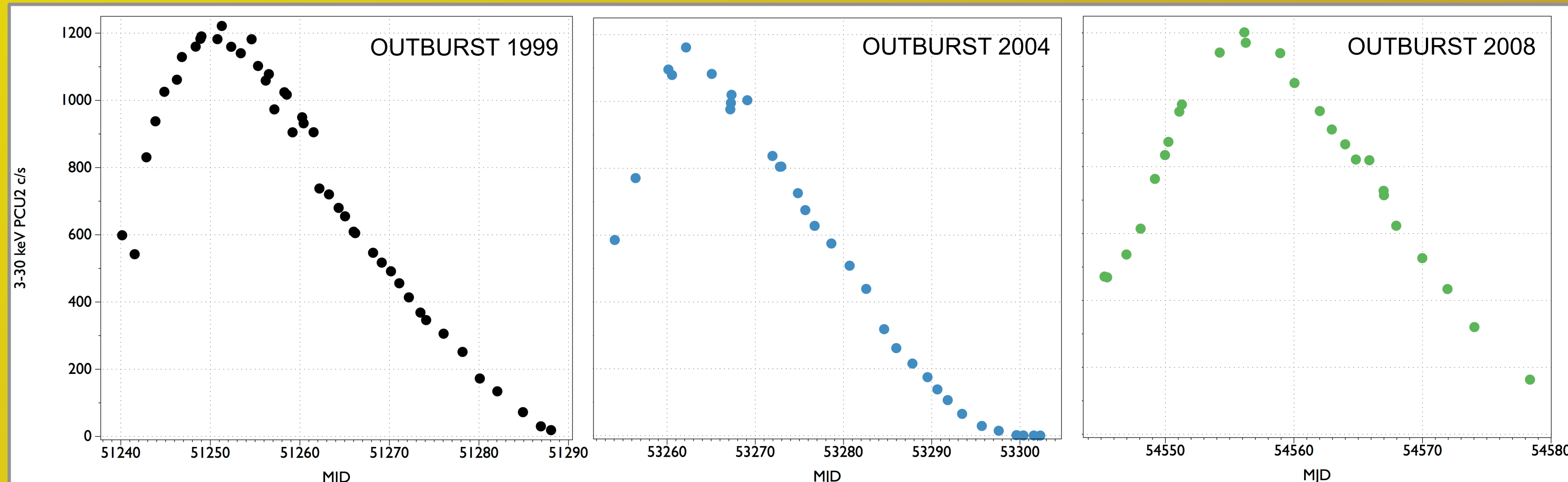


Figure 3: Photon Index against Luminosity and Time for outburst 2008. Each point represents a different observation.

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Spectral and Timing properties of accreting objects from X-ray binaries to AGN



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