Analysis of hard X-ray/high energy data from LSI+61°303 based on implications from its 4.6 yr periodicity

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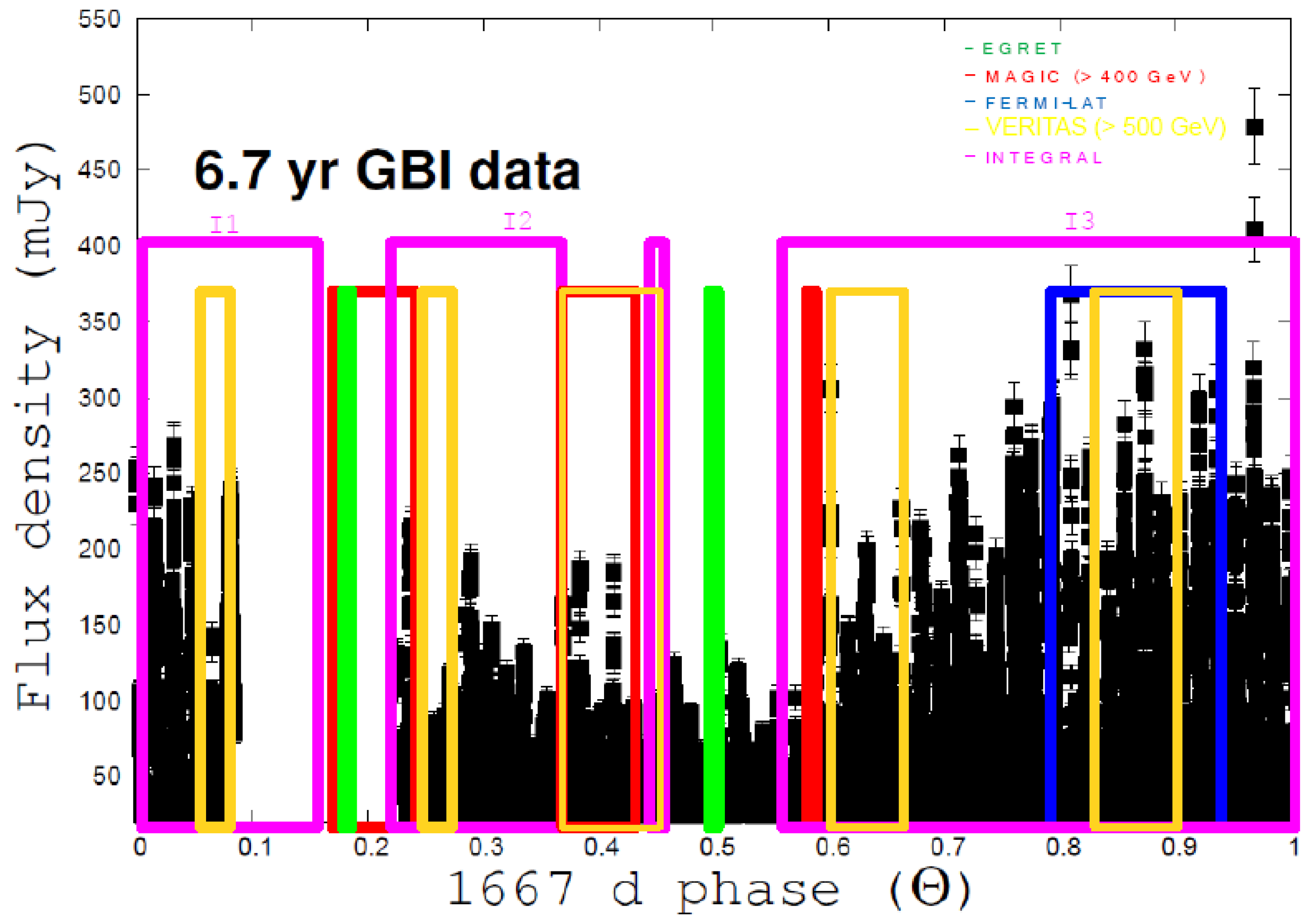
Abstract

The most peculiar radio characteristics of the TeV emitting high-mass X-ray binary LSI+61°303 are two periodicities: A large periodic outburst which exhibits the same period as the orbit (phase Φ) and a second periodicity of 1667 days (phase Θ) which modulates the orbital phase and amplitude of the large outburst. Recent analysis of the radio spectral index provides strong evidence for the presence of the critical transition from optically thick emission (related to a steady jet) to an optically thin outburst (related to a transient jet) as in other microquasars. In parallel, a switch from a low/hard X-ray state to a transitional state would be expected. We show how the critical transition from optically thick emission to an optically thin outburst is modulated by Θ. Folding over large Θ intervals mixes up different states and can yield a false picture of the emission behaviour of the source along the orbit. We therefore analyse the implications of this long period for treatment of hard X-ray/high energy data from LSI+61°303 obtained, e.g. with *Fermi*-LAT or INTEGRAL, taking into account this long-term periodicity.

High energy observations of LSI +61°303 vs. Θ



a)

b)

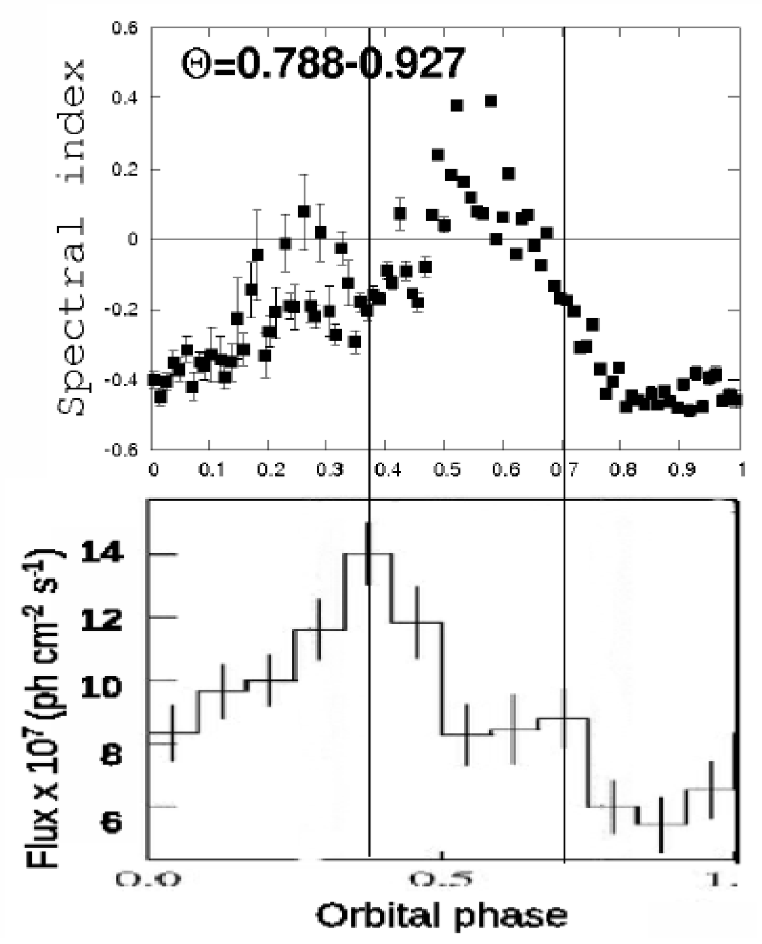
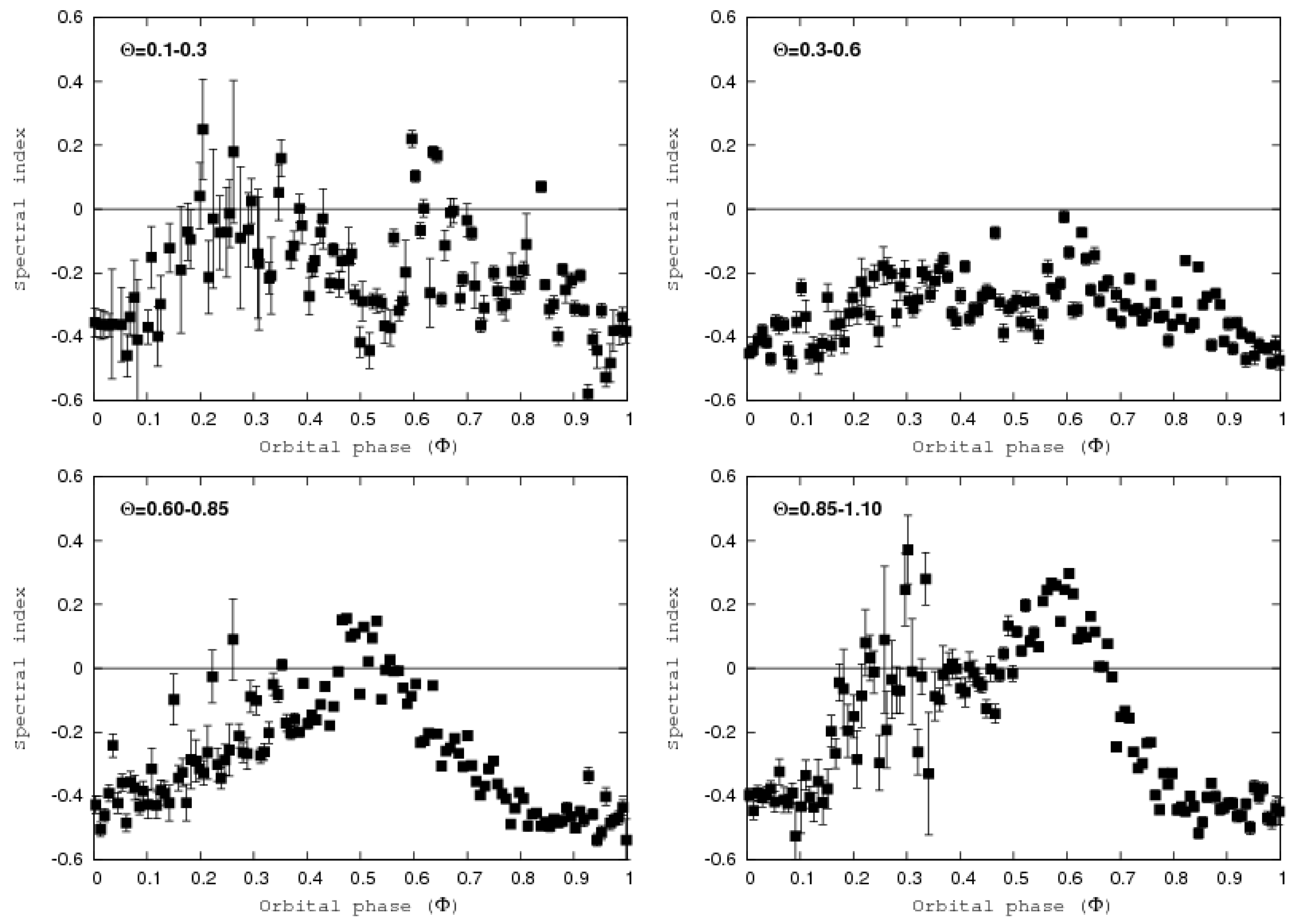


Fig.1 Top: Very high/high energy (VHE/HE) observations of LSI +61°303 by EGRET, MAGIC, *Fermi*-LAT, VERITAS and INTEGRAL shown in the context of the 4.6 yr radio period (θ) (Zimmermann & Massi 2011, in prep.). The three largest θ intervals where the source was observed with INTEGRAL are named here I1, I2 and I3.
Bottom (a &b): Radio and gamma-ray data observed at different epochs, but in the same θ interval (Massi, M. 2010, Mem. S.A.It. Vol. 82, 77). a): Radio spectral index of Green Bank Interferometer data at 8.3 GHz and 2.2 GHz (Massi & Kaufman Bernadó 2009, ApJ, 702, 1179M). b): *Fermi*-LAT data from Abdo et al. 2009, ApJ, 701L., 123A. Both gamma-ray peaks are correlated with a negative radio spectral index indicating the emission to originate from the transient jet.

High energy observations and the radio spectral index



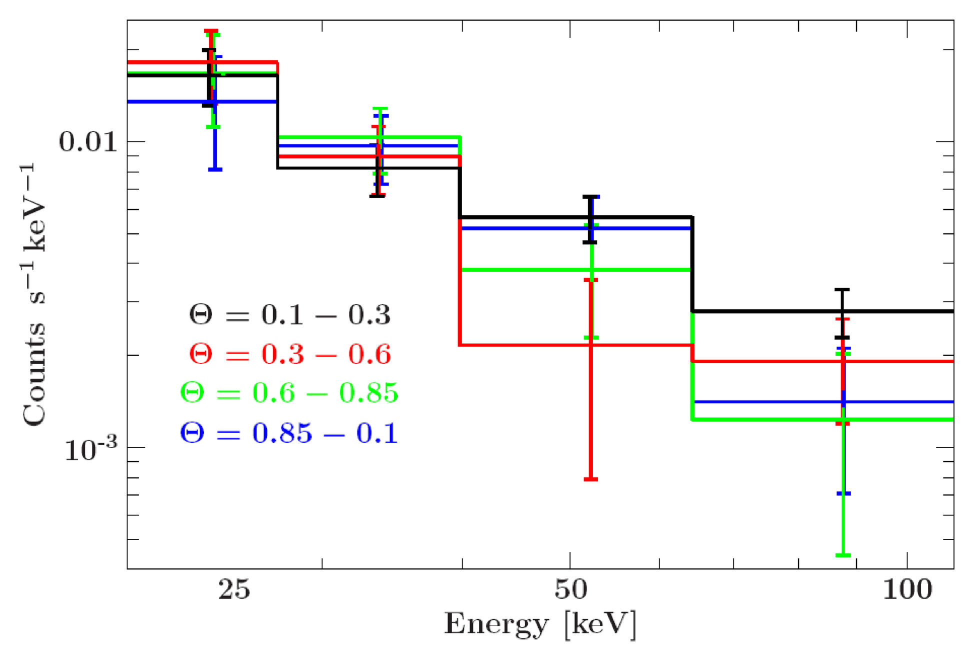


Fig.2: Top four panels: Radio spectral index evolution for LSI+61°303 along the orbit for four different Θ intervals (according to the ephemeris of Gregory, P. C. 2002, ApJ, 575) calculated for 6.7yr data taken with the Green Bank Interferometer (Zimmermann, L., Grinberg, V. et al., work in progress).
Bottom: Preliminary INTEGRAL/ISGRI spectra of LSI+61°303 (Zimmermann, L., Grinberg, V. et al., work in progress): to produce the spectra, all publicly available observations of LSI+61°303 were divided into the four Θ intervals. Since the source is faint ($\sigma_{det}\approx 11$ in the 20-40 keV energy band for 2 Ms overall exposure), the spectral extractions were performed with the mosa_spec tool, which extracts the spectra from the mosaic images at a given position on the sky (note: spectral points are slightly shifted in energy for viewing purposes).

Implications from the 4.6 yr periodicity

In the high-mass X-ray binary LSI+61°303, two clear radio periodicities are present, one coincident with its orbital period (phase Φ) and the other modulating the strength and orbital occurrence of the large radio outburst over a period of 1667 days (phase Θ) (Gregory, P. C. 2002, Gregory & Neish, C. 2002, ApJ, 580, 1133). By averaging radio spectral index data with respect to the long period, Massi & Kaufman Bernado (2009) have shown that the large radio outburst is accompanied by a transition typical for microquasars. This transition in radio corresponds to a transition between two distinct X-ray states. Here, we underline the importance of the periodicities in LSI+61°303 not only for the analysis of radio data, but also for the treatment of hard X-ray/high energy data:

With *Fermi*-LAT, two peaks were detected during the maximum of Θ (see Fig. 1) and a comparison with the radio spectal index yields a clear association with the transient jet (see Fig.1-bottom).

The orbital occurrence of the switch from optically thick (α>0) to optically thin (α<0) for the large radio outburst around apoastron (Φ≈0.6) is clearly different for different Θ intervals as seen in Fig 2.-top. This switch should be accompanied by an according switch in X-ray states from a low hard to a transitional state (e.g. steep power law). For the energy range covered by INTEGRAL/ISGRI (~20-500 keV, LSI+61303 detectable in the ~20-150 keV range), both periods must be taken into account, as both, the low hard and the transitional state, are present. Folding data for spectral analysis over too large Θ intervals could mix states and result in no longer unambiguously interpretable spectra. Folding, sampling and the flux during the spectral states determine the extend of mixing. Averaging across Φ will as well mix the different outburst episodes, but if not folded too strongly on Θ, the spectral results already show a difference in the contribution of the states (see INTEGRAL results in Fig. 2-bottom). For VHE/HE data in energy ranges covering only the transitional state, Φ should not be important for spectral analysis, because only emission from the transient jet can be detected at these energies.

We conclude that the long period yields crucial information about the emission processes in this intriguing source and that hard X-ray/high energy data from LSI+61303 should be analyzed on as small Θ intervals as possible. Nonetheless, if the sampling demands some folding over a longer interval, a comparison with radio spectral index data is mandatory.