Event-Sequence Time Series Analysis for Very-High Energy Light Curves

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Abstract. **A detailed analysis of the light-curves of AGNs and of some other classes of astronomical sources is essential for understanding their behaviour, since variability carries important signatures of the physical processes at work in them. In the particular case of blazars, the VHE end of the spectrum is the region where the most extreme temporal activity is observed, and its detailed characterization can be of great value if one can bypass the difficulties introduced by the low-photon statistics and extract the most information available from the data. In this paper we discuss the application of dynamic algorithms to the problem of detecting change-points in a unbinned one-dimensional event series, and discuss some of the benefits this approach can bring to the study of time variability at high-energies and ground-based gamma-ray telescopes.**

Keywords: **Ground-based gamma-ray astronomy, time-series analysis, event-sequence.**

Blazars constitute the primary class of extragalactic very-high energy (VHE) emitters in the sky and are among some of the brightest and most variable sources in the TeVs. Recently, extreme variability episodes have been detected by ground-based gamma-ray facilities – such as the two large outbursts of PKS 2155-304 ([1] and [2]) detected by HESS in July 2006, and the large Markarian 501 flare seem at the same year by the MAGIC telescope [6] – displaying the shortest known variability events for an AGN and presenting a multitude of flares giving rise to light-curve profiles comparable in complexity to those observed in X-rays. For the first time as well, a large enough photon statistics was available to allow a more detailed analysis of the variability properties: for example, over 6000 gamma-like events were registered for PKS 2155-304 in the night of 28th July, with a surprising number of $\sim$ 1000 events within a window of 100s around the brightest features, which had themselves an unprecedent average gamma-ray rate of over 1 Hz.

These events have for the first time allowed detailed time-series analysis to be performed and more evolved algorithms to be applied to ground-based gamma-ray light-curves. In particular, unbinned methods have been applied [6] or developed [4] as optimal approaches to exploit the richness of the datasets. Unbinned methods, although very rarely used in almost any area of high-energy astronomy, have the advantage of being naturally better suited for dealing with the low-counts regime ($\sim$ 0.1 Hz) which are still the dominant circumstance in the field. With the coming of the new generation of ground-based telescopes in the next few years, which should bring significant improvements in sensitivity [7], the development and incorporation of such time-series approaches to the standard analysis softwares promises to be of great benefit for the research.

We have studied in detail some theoretical aspects of the applicability of unbinned methods [3] to ground-based telescope data, and have incorporated Scargle's *Bayesian blocks* algorithm ([8] and [5]) into our analysis software; we are presently simulating the performance of the algorithm on simulated H.E.S.S. data-sets as well as testing its efficiency on the analysis of some particular sources.

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