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The *Swift* knife: the unique *Swift* long-term monitoring program on 3C 454.3

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Abstract. The blazar 3C 454.3 is a well-known, extremely variable flat-spectrum radio quasar which exhibited the most intense gamma-ray flares detected up to now. Thanks to the *Swift* innovative and unique pointing strategy, it has been possible to monitor this source in the UV and X-ray energy bands on time-scales comparable to the ground-based optical and radio ones. The long-term multi-wavelength light-curves allowed us to obtain detailed information on time-lags between the flux emission in different energy bands, to investigate the properties of the jet during the most intense gamma-ray flares, and to study the radiation mechanisms responsible for the emission at different frequencies. We will review the results obtained so far on the above topics, highlighting the crucial role of *Swift* and its breakthrough in the X-ray studies of blazars.

Key words. galaxies: active – galaxies: quasars: general – galaxies: quasars: individual: 3C 454.3 – galaxies: jets – radiation mechanism: non thermal.

1. Introduction

The flat-spectrum radio quasar 3C 454.3 (PKS 2251+158; $z = 0.859$) is one of the most investigated γ-ray blazars, thanks to its high dynamic range flux variations from the radio to the γ-ray energy bands. Since 2007, AGILE and *Fermi* detected several γ-ray flares from 3C 454.3 (see Vercellone et al. 2010, for a review of the AGILE results). The rapid analysis of the γ-ray data allowed us to provide almost real-time alerts to other Observatories at different wavelengths, from radio up to the hard X-ray. This allowed us to obtain detailed multi-wavelength light-curves which can be used to extract time-selected SEDs. Figure 1 shows the long-term (2005–2012) X-ray (*Swift*/XRT, 0.3–10 keV) and γ-ray (*Fermi*/LAT, $E > 100$ MeV) 3C 454.3 light curves. The two light-curves show a good correlation during the most prominent flares and during the most recent prolonged γ-ray quiescent period. Thanks to the *Swift* innovative and unique pointing strategy, it has been possible to monitor this source in the UV and X-ray energy bands on time-scales comparable to the ground-based optical and radio ones. The long-term multi-wavelength light-curves allowed us (Vercellone et al. 2010) to obtain detailed information on time-lags between the flux emission in different energy bands, to investigate the properties of the jet during the most intense gamma-ray flares, and to study the radiation mechanisms responsible for the emission at different frequencies. In particular,

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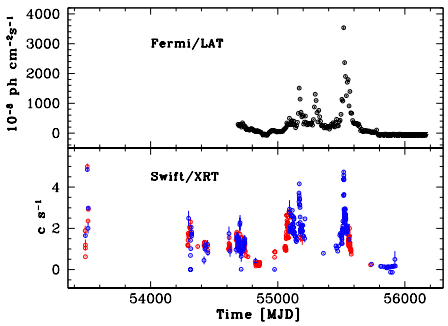

Fig. 1. Long-term (2005–2012) X-ray (*Swift*/XRT, 0.3–10 keV) and γ-ray (*Fermi*/LAT, $E > 100$ MeV) 3C 454.3 light curves. Red and blue points represent photon counting (PC) and windowed timing (WT) data, respectively.

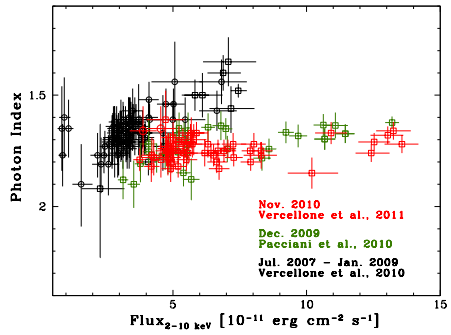

Fig. 2. The X-ray photon index as a function of the 2–10 keV flux during different observing campaigns. Data from Vercellone et al. (2010), Pacciani et al. (2010), and Vercellone et al. (2011).

Vercellone et al. (2011) showed that, during extreme γ-ray flares, the harder-when-brighter correlation noted during low and intermediate γ-ray states (and discussed in Vercellone et al. 2010) does not hold anymore, leading to an achromatic increase of the X-ray flux. Figure 2 shows the X-ray photon index as a function of the 2–10 keV flux during different observing campaigns whose data have been already published. Vercellone et al. (2011) describe the harder-when-brighter trend in terms of a dominant contribution of the external Compton off the disk seed photons, EC(Disk), over the synchrotron self-Compton (SSC) component, probably due to an increase of the accretion rate. The constant X-ray photon index during the extreme γ-ray flares in 2009 and 2010 can be interpreted in terms of a balance of the SSC contribution with respect to the EC(Disk), whose net result is a roughly achromatic increase of the X-ray emission.

2. On-going work

We are currently monitoring 3C 454.3 with *Swift* in order to extend the study of the X-ray photon index relation w.r.t. the flux at the low intensity end. As discussed in Vercellone et al. (2010, 2011), while the intermediate and high X-ray flux level portion of the diagram shown in Figure 2 is well sampled, the low-flux portion does not allow us to establish a firm relation between the two quantities. The *Fermi*/LAT data show that during 2012 the quiescent period is still ongoing, suggesting our monitoring program is quite timely. Our 7 ks/month monitoring will allow us to obtain a reliable determination of both X-ray photon index and flux. Moreover, we are monitoring 3C 454.3 with all *Swift*/UVOT filters, in order to investigate the disk features which emerge in the spectral energy distribution during particularly low states (e.g., Vercellone et al. 2010). Our monitoring will allow us to extend our study of 3C 454.3 X-ray spectral properties, and improve our current understanding of this spectral trend in terms of balance of different emission components.

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