Swift and AGILE: a successful synergy

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ABSTRACT

The beginning of the 21st Century heralded the advent of two satellites that revolutionised the high-energy astrophysics. The AGILE satellite, for the first time, used a Silicon pair conversion detector for γ-ray detection, allowing for a leap forward with respect to previous spark chamber technology. The *Swift* satellite combined optical, UV and X-ray telescopes with an unprecedented repointing capabilities. These allowed us to investigate flaring celestial sources right in time and simultaneously from optical up to GeV energy bands. In this contribution we describe some relevant AGILE scientific observations of different classes of sources, from GRBs to AGNs and Galactic sources, which not only benefited from *Swift* observations but for which *Swift* demonstrated its pivotal and unique contribution.

AGILE

The **A**strorivelatore **G**amma ad **I**mmagini **LE**ggero (AGILE) satellite [1] was a mission of the Italian Space Agency (ASI) devoted to high-energy astrophysics. It was launched on 23 April 2007 by the Indian PSLV-C8 rocket from the Sriharikota ISRO base (India). It ceased its operations on 18 January 2024 and subsequently re-entered the Earth's atmosphere on 14 February 2024.

Cyg X-3

Cygnus X-3 is the brightest radio source among all known micro-quasars. It is a high-mass X-ray binary, whose companion star is a Wolf-Rayet star at a distance of about 7–10 kpc and with an orbital period of 4.8 h. Owing to its very tight orbit, the compact object is totally enshrouded in the wind of the companion star.
Fig. 1 shows the *Swift*, AGILE, RXTE and radio data accumulated in the period 2007 November 2 - 2009 July 29.

Key findings

There is a strong anti-correlation between the hard X-ray and γ-ray emission: every time the AGILE-GRID detects γ-ray activity the system exhibits a deep local minimum of the ***Swift*/BAT** hard X-ray light curve (count rate < 0.02 counts cm^{-2} s^{-1}), a few days before intense radio outbursts. This repetitive temporal coincidence between the γ-ray transient emission and spectral state changes of the source turns out to be the spectral signature of γ-ray activity from this microquasar. **These γ-ray events may thus reflect a sharp transition in the structure of the accretion disk and its corona, which leads to a rebirth of the micro-quasar jet and subsequent enhanced activity in the radio band.**

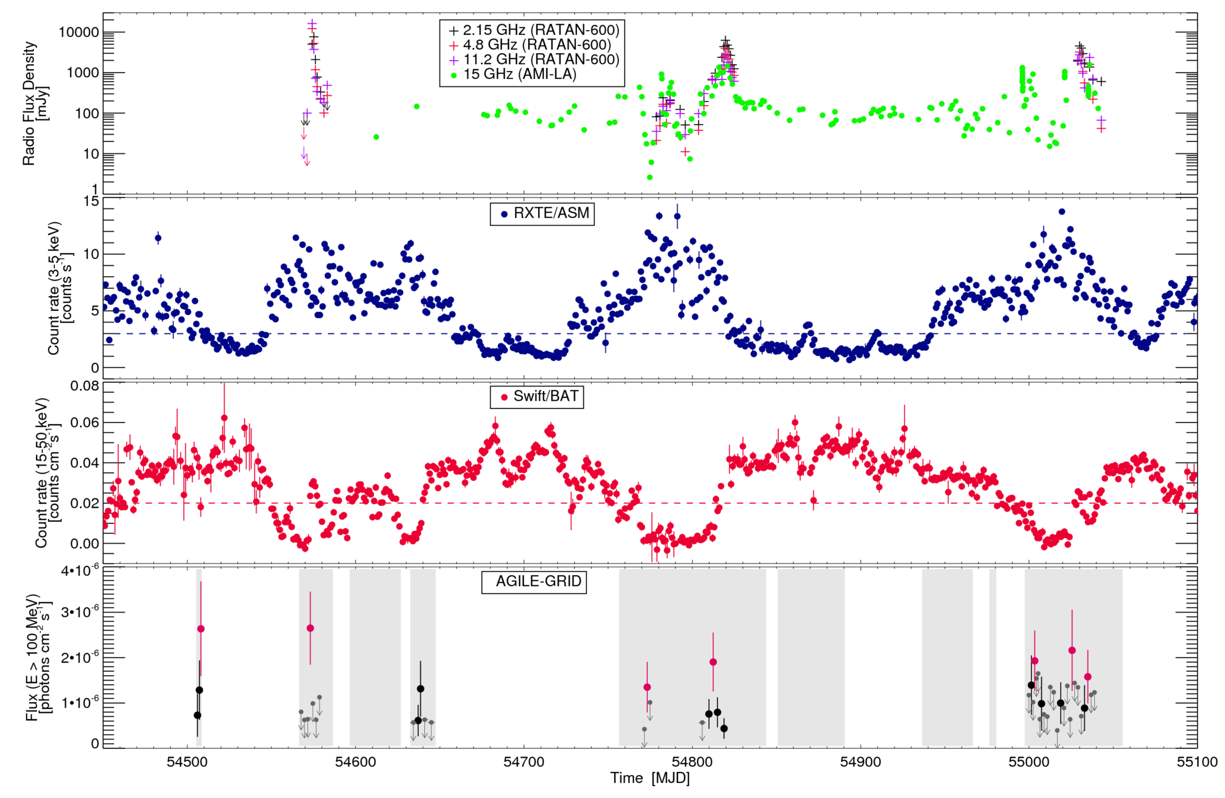

Figure 1: Cyg X-3 multi-wavelength light-curve. From [2].

3C 454.3

3C 454.3 is a well known flat-spectrum radio quasar (z = 0.859) with a clear signature of the accretion disc in low states and it is the first blazar detected in a flaring state by AGILE in 2007. In the following years, it also temporarily became the most intense γ-ray source detected by AGILE above 100 MeV. AGILE initiated several multi-wavelength campaigns on 3C 454.3, which allowed us both to study the different spectra energy distributions and to discuss innovative flaring models to account for different flaring periods.

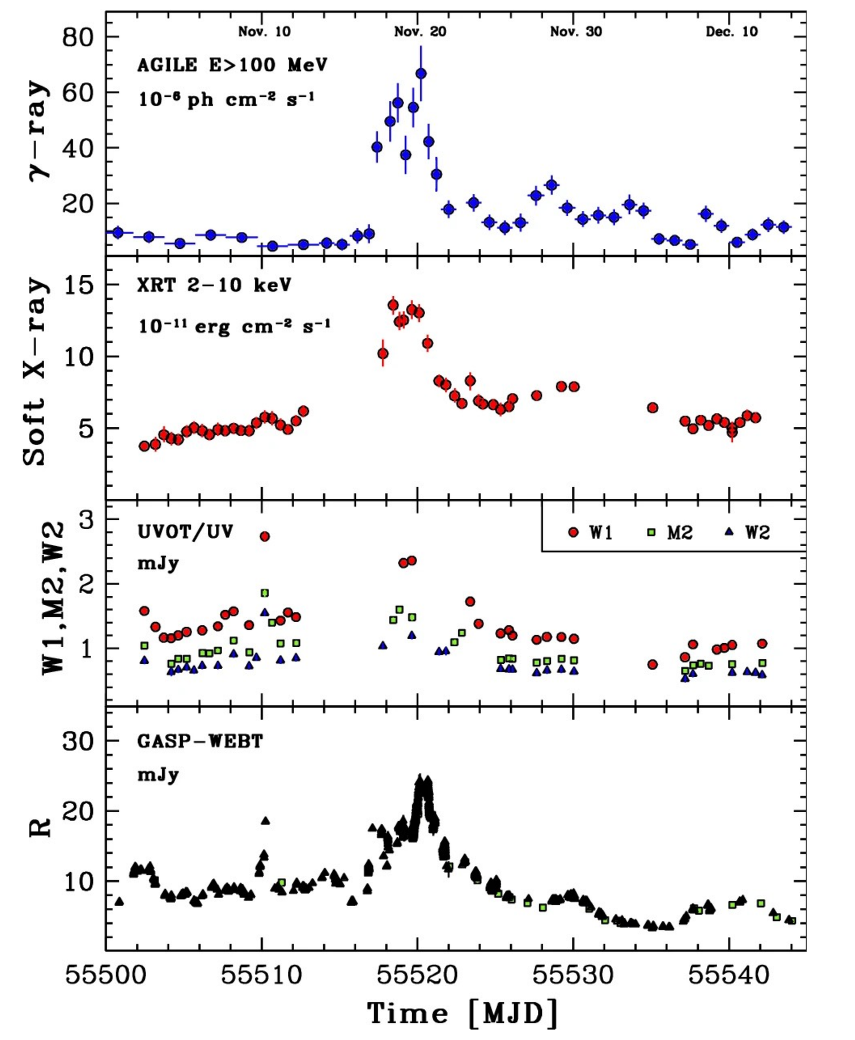

Figure 2: 3C 454.3 multi-wavelength light-curve. Adapted from [3].

Key findings

Fig. 2 shows a short (~24h) γ-ray orphan, optical-UV flare detected by ***Swift*/UVOT** at about on 2010 November 10 (MJD 55510), associated with a modest increase in the ***Swift*/XRT** band. **This peculiar behaviour may challenge the model of a uniform external photon field responsible for the high-energy emission, suggesting an energetic particle ignition taking place in lower-than-average density photon region causing the orphan optical flare.**

GRB 221009A

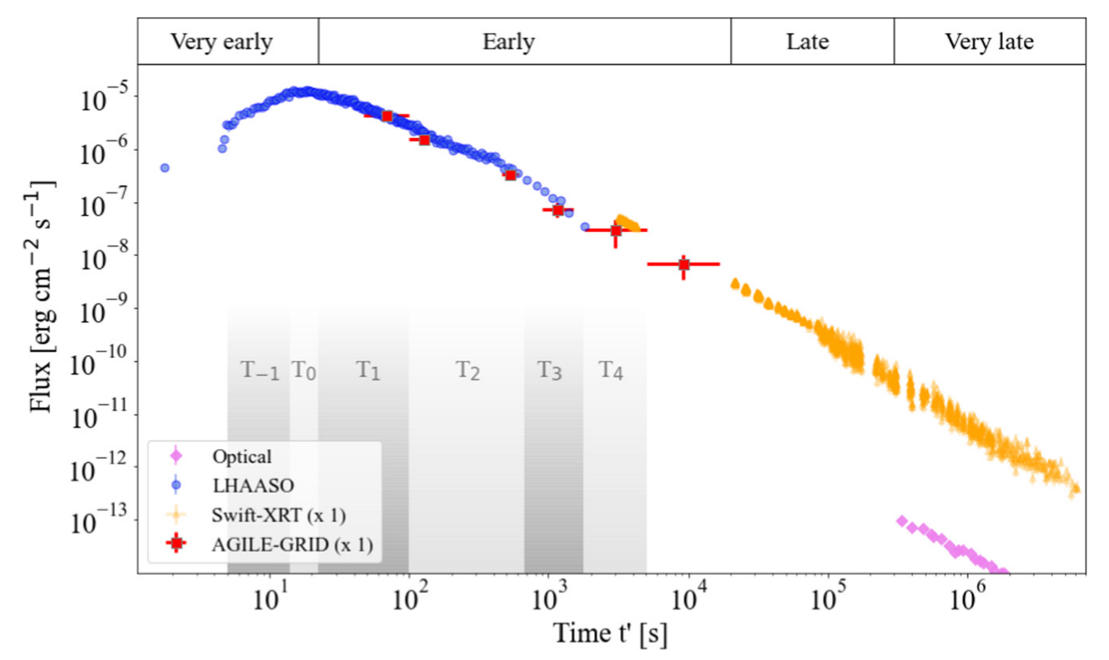

Figure 3: GRB 221009A time-decay curve. From [4].

GRB 221009A is the brightest γ-ray burst ever detected. The LHAASO detection up to a few TeVs challenges the current γ-ray propagation paradigm [5]. With an unprecedented brightness and duration, GRB 221009A offers an exceptional opportunity to investigate the physical mechanisms driving such powerful explosions. AGILE detected GRB 221009A proving for the first time a phase of coexistence of MeV and GeV emissions during the transition between prompt and afterglow emission [4].

Key findings

Fig. 3 shows the LHAASO, AGILE/GRID and ***Swift*/XRT** flux evolution during different afterglow phases, covering a factor $\sim 10^6$ in time and $\sim 10^9$ in energy. **We find that the adiabatic fireball evolution in the slow-cooling regime provides a viable scenario in good agreement with observations.**

References: [1]: Tavani M. et al., 2009, A&A, 502, 995; [2]: Piano G., et al., 2012, A&A, 545, A110; [3]: Vercellone S. et al., 2011, ApJL, 736, L38; [4]: Foffano L., et al., 2024, ApJL, 973; [5]: Galanti et al., 2023, PRL, 131, 251001.