High-redshift blazars with AGILE

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ABSTRACT

High-redshift (z>2) blazars have spectral energy distributions whose inverse Compton peak usually lies in the MeV-GeV energy range. In particular, the AGILE satellite investigated 4C +71.07 and PKS 1830-211 triggering multi-wavelengths observations from the radio to the γ-ray energy bands, in response to γ-ray flares. We report on the multi-wavelength observations, discussing the modelling of their spectral energy distributions, whose extreme Compton dominance (CD>100 during the flares) may challenge the canonical one-component emission model, requiring alternative models. Moreover, their high-redshifts make them excellent candidates for future γ-ray missions such as COSI and e-ASTROGAM.

RATIONALE

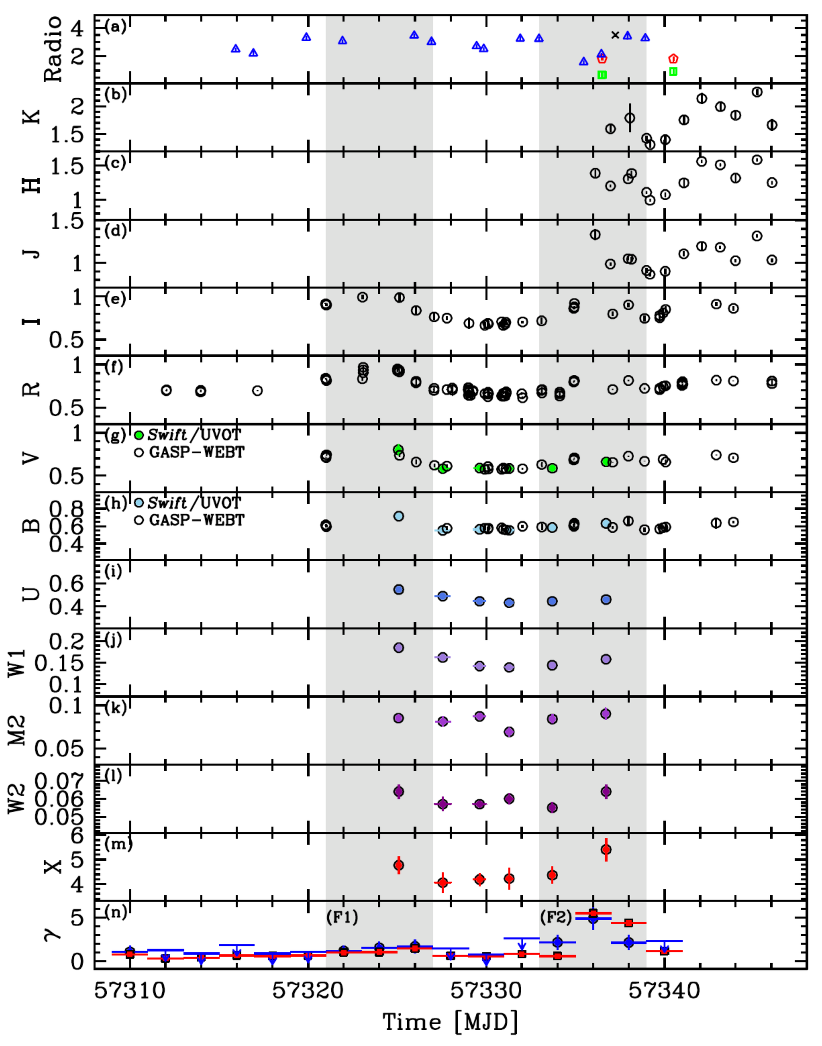
Among the Fermi-LAT 4FGL-DR2 Catalogue, 102 sources (with $|b| > 10°$) have z>2. Most of these high-redshift jetted sources are FSRQs (*95*, 93%), while BL Lacs (*5*, 5%) and changing-look AGNs (*2*, 2%) are marginal (see *Foschini et al., 2022*). We focus on two high-redshift sources that have been investigated with AGILE, 4C +71.07 and PKS 1830-211.

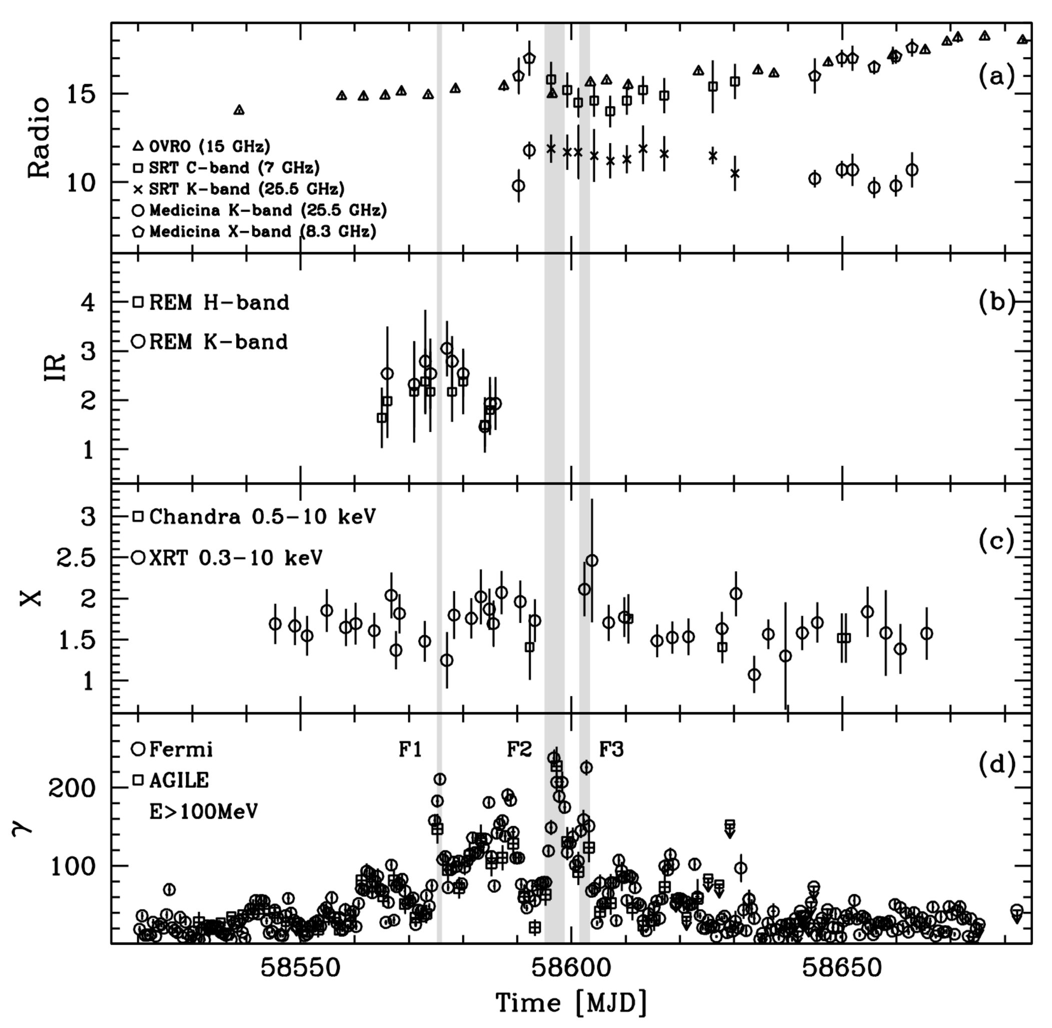
4C +71.07

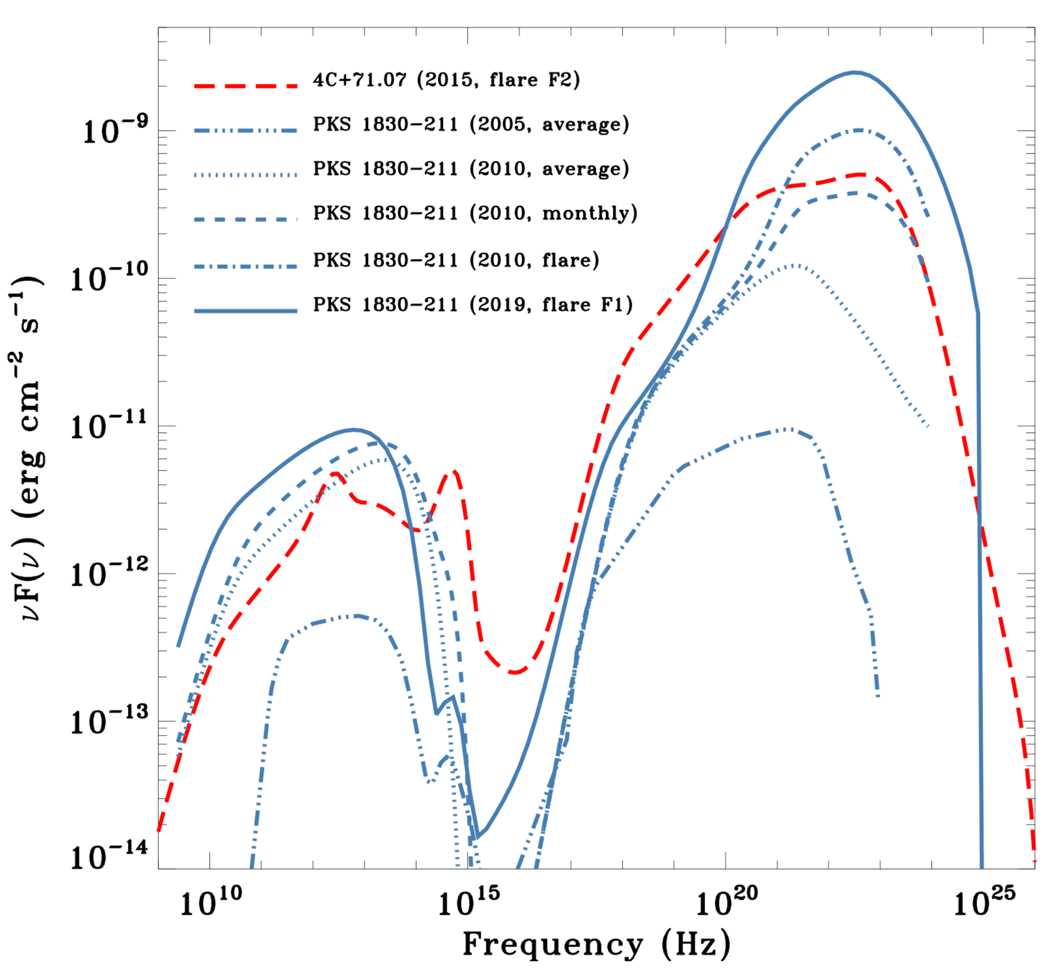
The flat-spectrum radio quasar 4C+71.07 is a high-redshift (z = 2.172) jetted source. The AGILE collaboration reported on the high γ-ray activity of this source in October–November 2015. AGILE detected two separate flares (F1 and F2) with fluxes above E>100 MeV of F1= (1.2 ± 0.3) × 10^{-6} photons cm^{-2} s^{-1} and F2 = (3.1 ± 0.6) × 10^{-6} photons cm^{-2} s^{-1}, respectively.

PKS 1830-211

PKS 1830–211 is a γ-ray-emitting, high-redshift (z = 2.507), and lensed FSRQ. The source reached its maximum flux above 100 MeV, F = (2.28 ± 0.25) × 10^{-5} photons cm^{-2} s^{-1}, around 24 April 2019. This flux level is unprecedented for this source, and it is one of the largest ever detected in γ-rays from blazars at z > 2.







Left panel: multi-wavelength light curves for the observing campaign on 4C +71.07. The gray-dashed areas mark the time intervals F1 (MJD 57,321.0–57,327.0) and F2 (MJD 57,333.0–57,339.0) used to accumulate the almost simultaneous spectral energy distributions. **Middle panel:** PKS 1830–211 multi-wavelength light curves. The shaded areas correspond to the major γ-ray flares F1, F2, and F3, when the spectral energy distributions were computed. Arrows mark 3σ upper limits. **Right panel:** Comparison of the 4C +71.07 and PKS 1830–211 SEDs. Only the sum of different emission components is reported. Data from 4C +71.07 (2015), PKS 1830–211 (2005), (2010, three distinct states), and (2019). See *Vercellone et al., 2024* and references therein, for details.

DISCUSSION

We can now compare the SEDs of these two sources. The right panel of the Figure shows the SEDs for both 4C +71.07 and PKS 1830–211, the latter in different epochs and emission states. We note that, during the flaring states, both sources are within a factor of about 10 in flux. In particular, the isotropic γ-ray luminosity for 4C +71.07 at its maximum is $L^{\rm iso}_{\gamma,E>100{\rm MeV}} \approx 3 \times 10^{49}$ erg s^{-1}, while the Eddington luminosity is $L_{\rm Edd} \approx 6 \times 10^{47}$erg s^{-1}, assuming a black hole mass of $M_{\rm BH} = 5 \times 10^9\, M_{\odot}$. For PKS 1830–211, we obtain $L^{\rm iso}_{\gamma,E>100{\rm MeV}} \approx 8.6 \times 10^{50}$ erg s^{-1}, while $L_{\rm Edd} \approx 6 \times 10^{46}$ erg s^{-1}, where for the latter, we assume a black-hole mass of $M_{\rm BH} = 5 \times 10^8\, M_{\odot}$. A notable difference between the flaring and the average state of PKS 1830–211 is the value of the Compton dominance (CD), i.e., the ratio between the inverse Compton and the synchrotron peaks. During the average 2005 state, the CD is of the order of ≈20, rising to ≈100 in 2010 and topping at >200 in 2019. Such high CD values may challenge the canonical one-component emission model, requiring alternative models to explain this remarkable SED, such as the "mirror model" (*Tavani et al., 2015*) or "jet-cloud interaction model" (*Araudo et al., 2010*).

ACKNOWLEDGEMENTS

We acknowledge financial contributions of the Next Generation EU funds within the National Recovery and Resilience Plan (PNRR), Mission 4 - Education and Research, Component 2 - From Research to Business (M4C2), Investment Line 3.1 - Strengthening and creation of Research Infrastructures, Project IR0000012 – "CTA+ - Cherenkov Telescope Array Plus".

References: Araudo A.T., et al., 2010, A&A, 522, A97; Foschini L. et al., 2022, Universe, 8, 587; Tavani M. et al., 2015, ApJ, 814, 51; **Vercellone S. et al., 2024, Universe, 10, 153**