Monitoring blazar variability with the Whole Earth Blazar Telescope (WEBT)

https://www.oato.inaf.it/blazars/webt

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History

1991-2000 Compton Gamma Ray Observatory (CGRO)

➪ The extragalactic γ-ray sky is full of blazars

1997 birth of the WEBT - John Mattox (BU, USA)

➪ support to the CGRO observations with continuous optical monitoring

2000 Massimo Villata President + Claudia M. Raiteri Executive Officer

➪ +radio+near-IR

Team: ~ 200 observers; more than 150 telescopes (small, medium and large size)

AFRICA Egypt

AMERICA Argentina,Mexico,USA

ASIA China,India,Japan,Taiwan,Uzbekistan

EUROPE Bulgaria, Crimea, Finland, Georgia, Germany, Greece, Italy, Russia, Serbia, Spain

Main collaborations

AGILE, Fermi, MAGIC

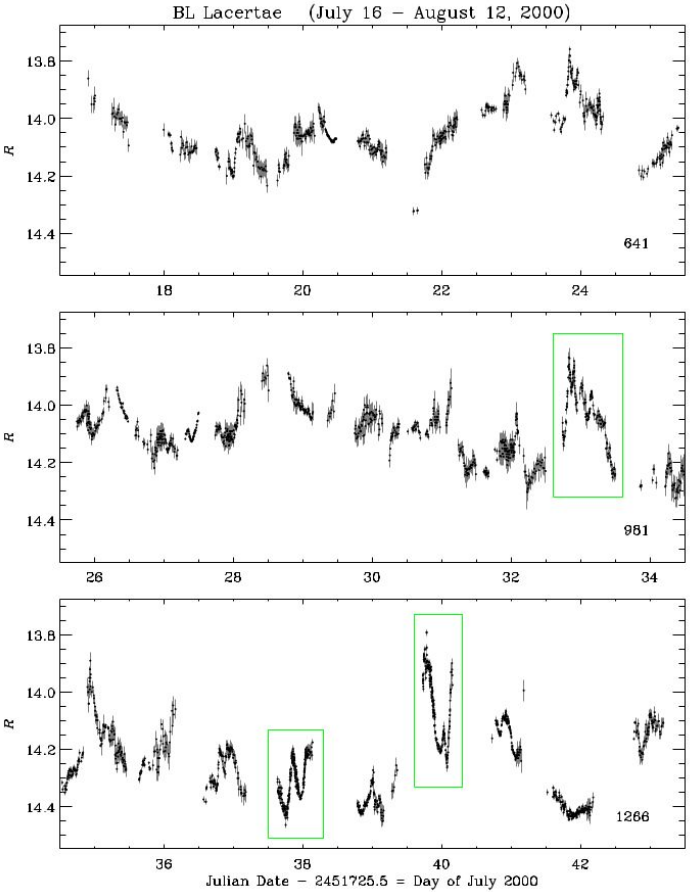
Deliverables

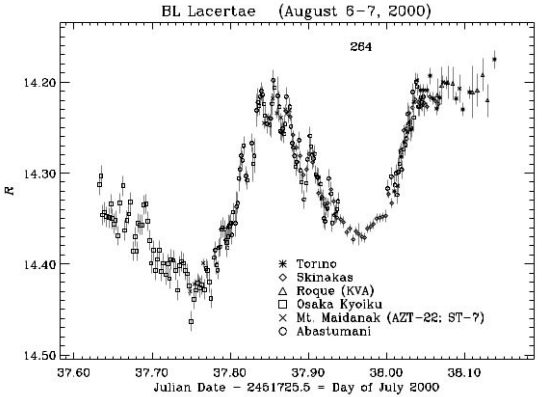
- photometry + polarimetry + spectroscopy
- satellite GO observations: XMM-Newton, Swift, TESS
- archive, with data available after publication
- models to explain blazar variability
- 272 papers by the WEBT in the NASA ADS, 140 refereed, including 3 papers on Nature, 2 of which led by the WEBT

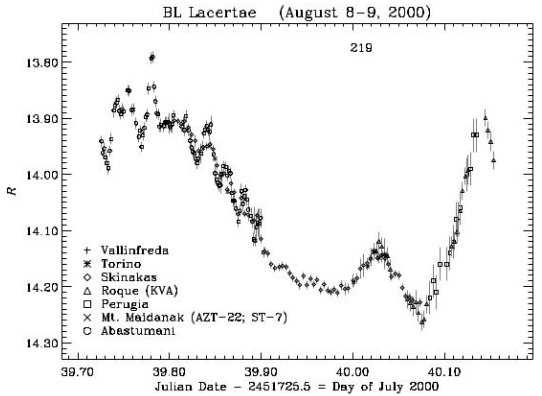
Optical monitoring with exceptional sampling: BL Lacertae

Villata et al. 2002 (A&A, 390, 407)

More than 15000 observations by 24 telescopes in 11 countries

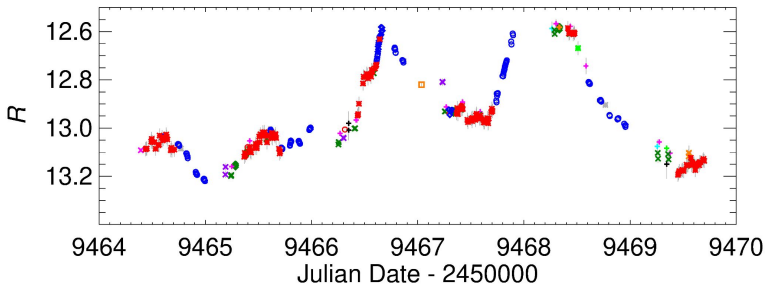


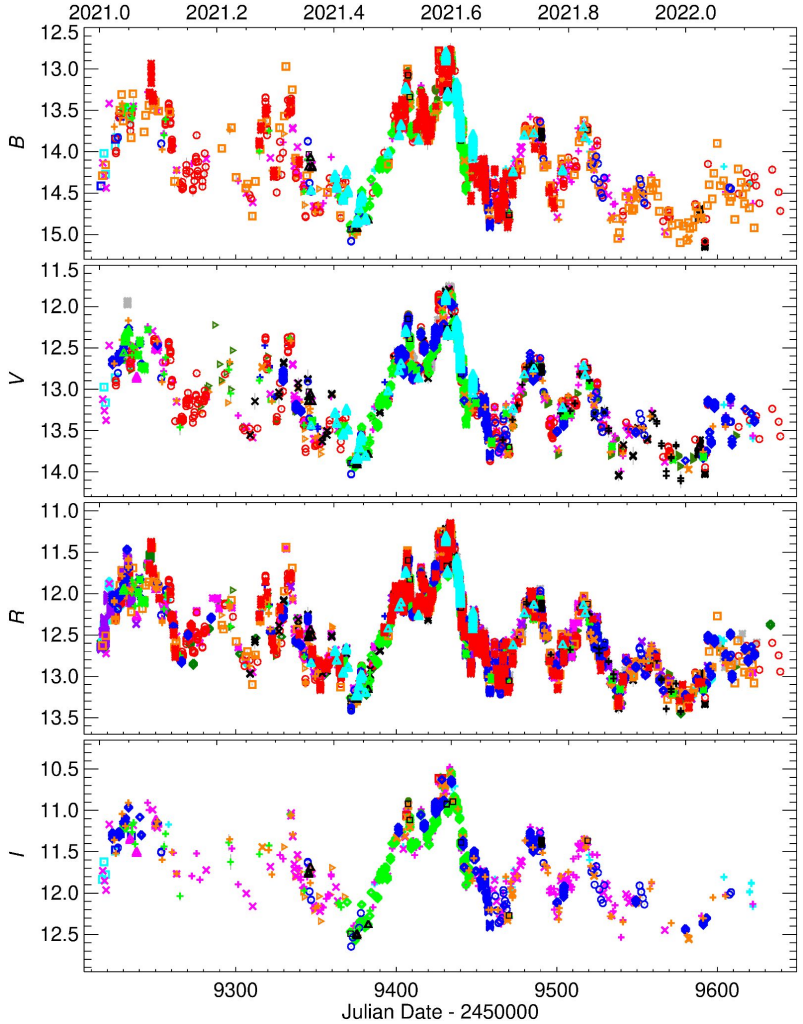




Optical monitoring with exceptional sampling: BL Lacertae

About 25000 data from 41 telescopes in 14 countries



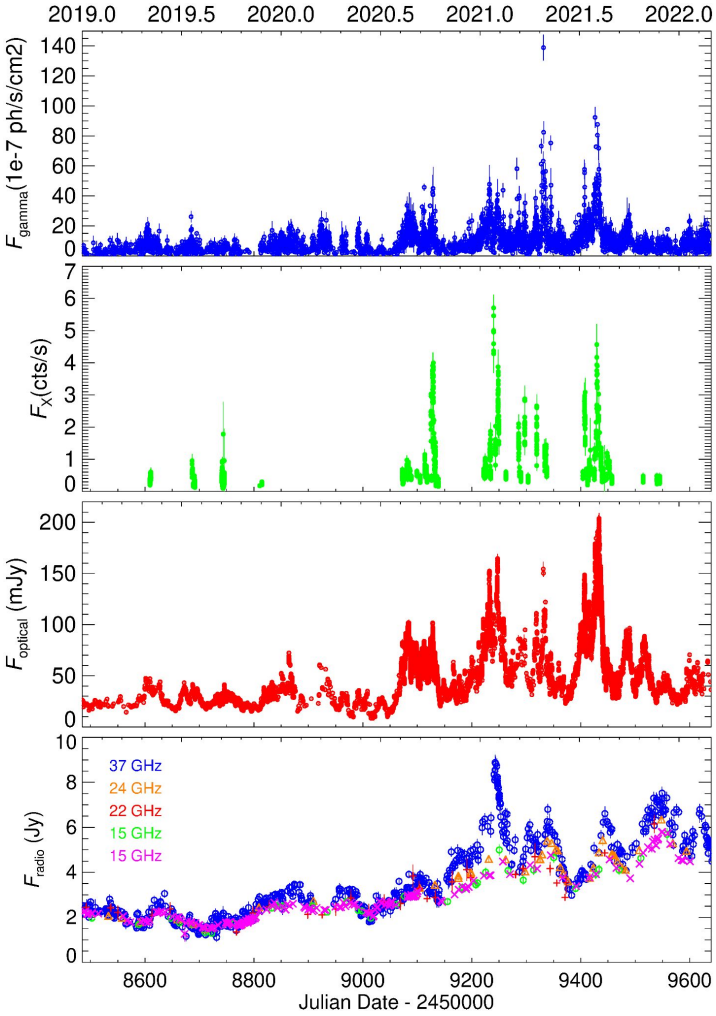


Raiteri et al. 2023, MNRAS, 522, 102

Multiwavelength behaviour: BL Lacertae

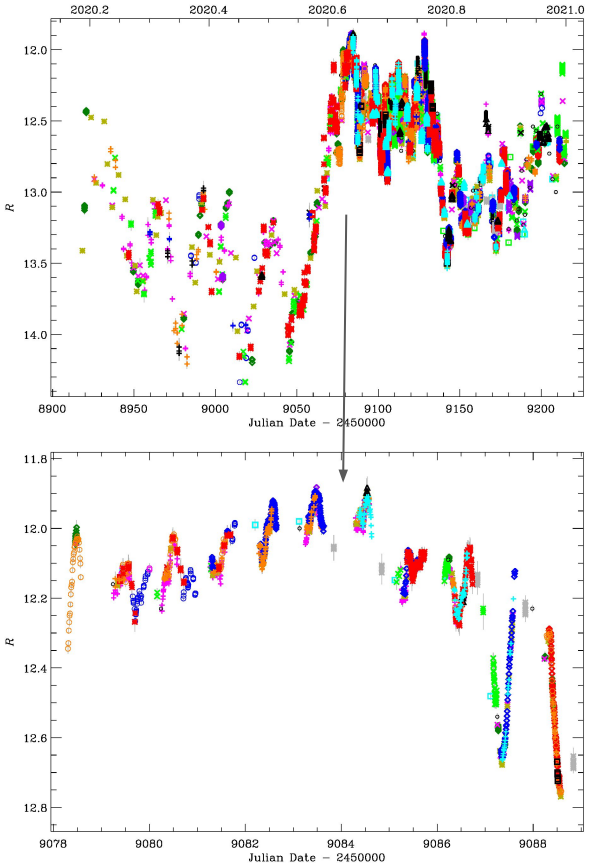
35074 data points in the R band in the period 2019-2022 from 54 telescopes in 48 observatories

Raiteri et al., in preparation



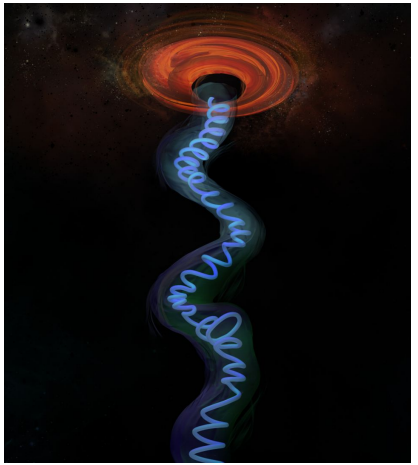
Rapid quasi-periodic oscillations in the relativistic jet of BL Lacertae

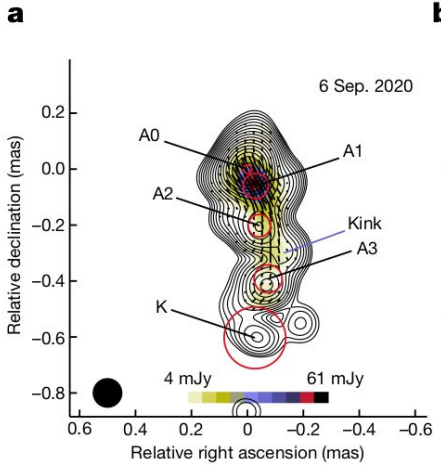
Jorstad et al. 2022, Nature, 609, 265

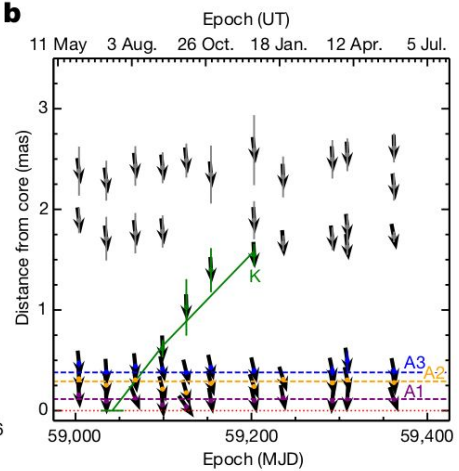


Transient quasi-periodic oscillations (QPOs) with P~13 hr detected in optical flux, optical polarization degree, and gamma-ray flux

QPOs triggered by a ***kink instability*** in the jet, when an off-axis perturbation (shock) met a standing shock

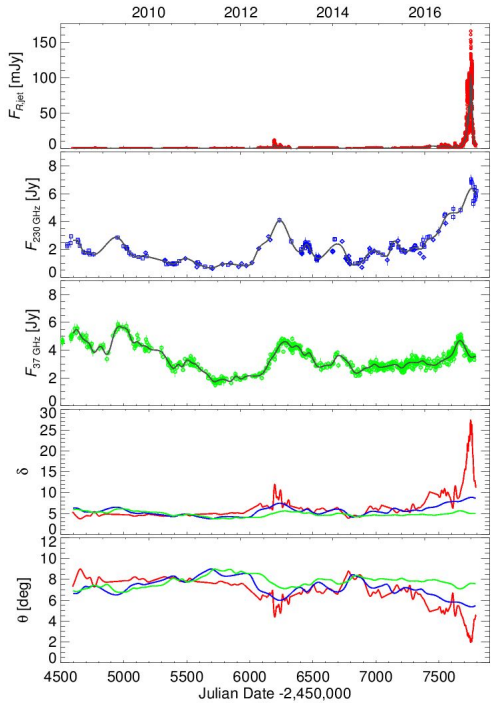


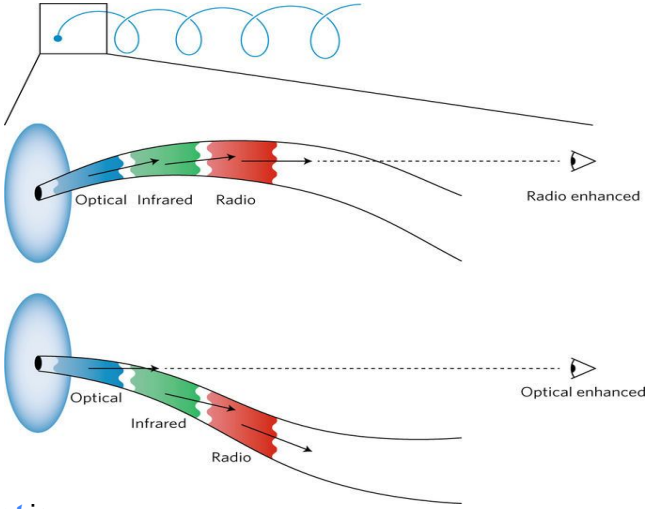




Blazar spectral variability as explained by a twisted inhomogeneous jet

CTA 102, Raiteri et al. 2017, Nature 552, 374





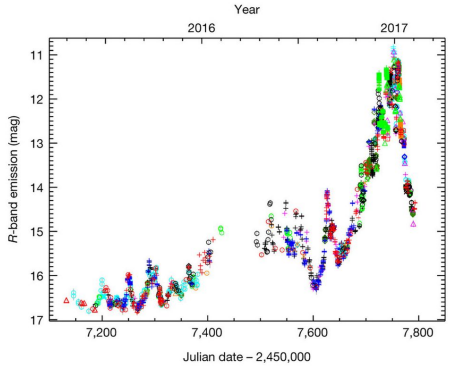
The ***jet*** is:

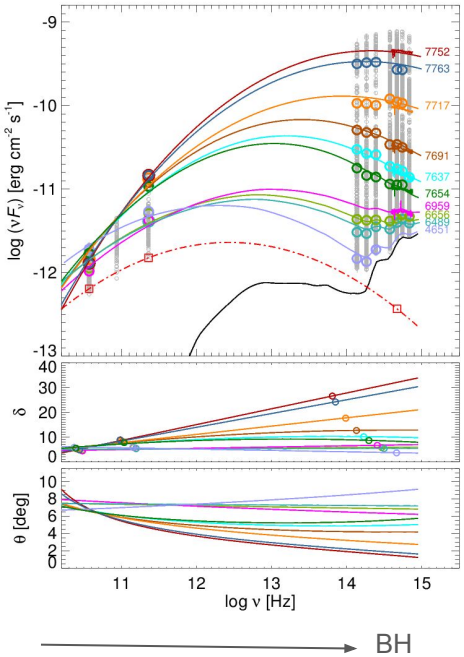
inhomogeneous: radiation at different frequencies emitted from different regions

curved: different emitting regions have different viewing angles = different Doppler factor

$$\delta=[\Gamma(1-\beta\cos\theta)]^{-1}$$

twisting: the viewing angle varies in time because of internal (instabilities) and/or external (orbital motion, precession) reasons





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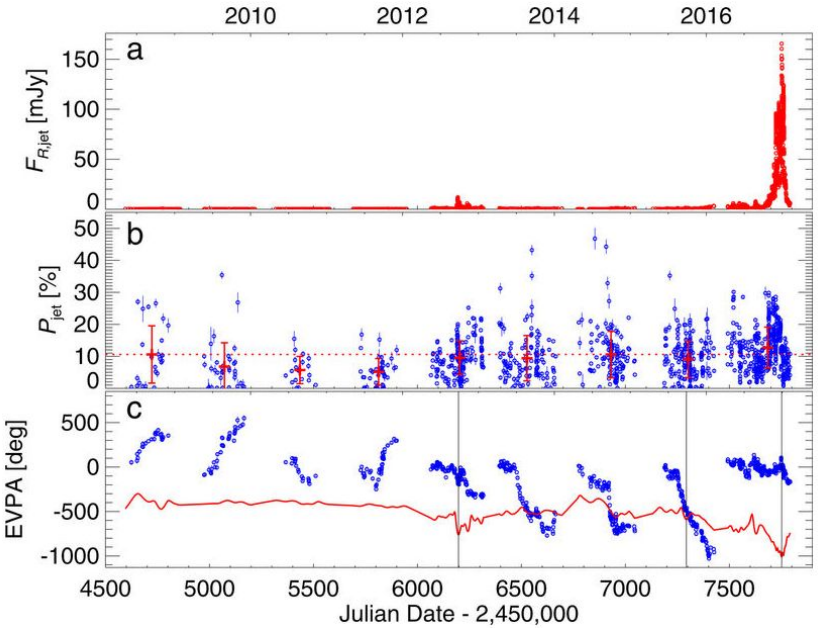
Polarimetric behaviour

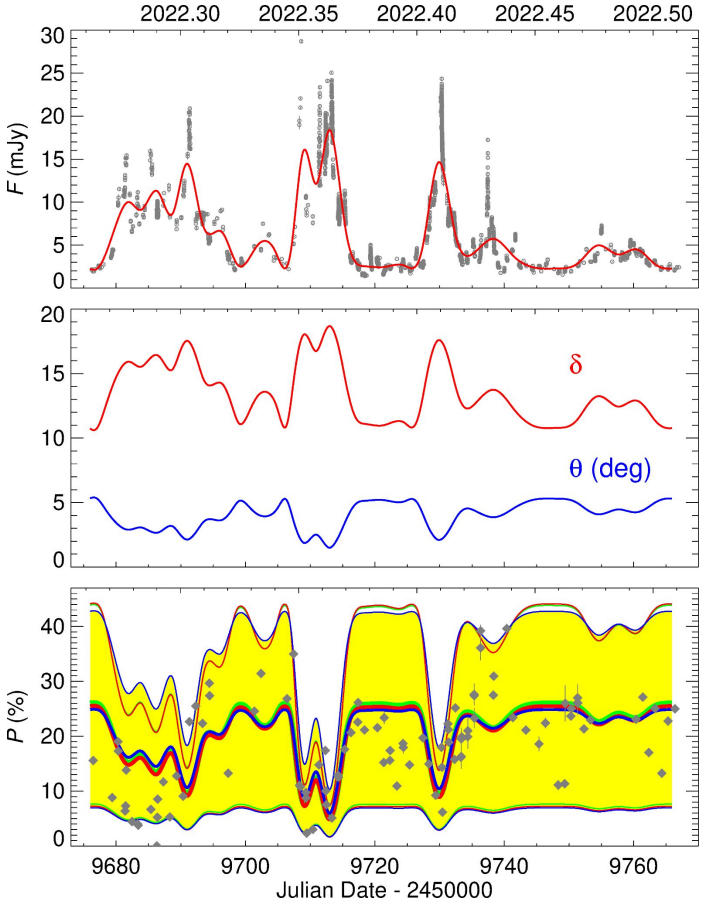
Both polarization degree (P) and angle (EVPA) very variable.

Wide rotations of EVPA

EVPA and P_{jet} usually not correlated with F_{jet}

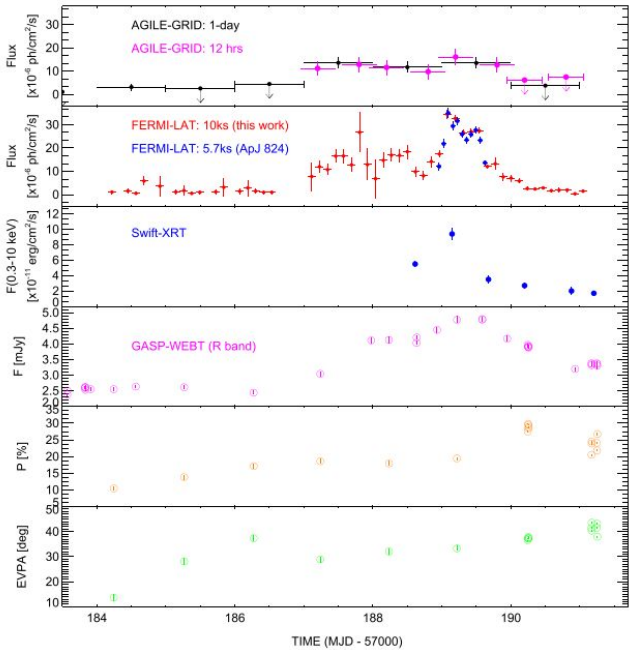


CTA 102, Raiteri et al. 2017, Nature, 552, 374

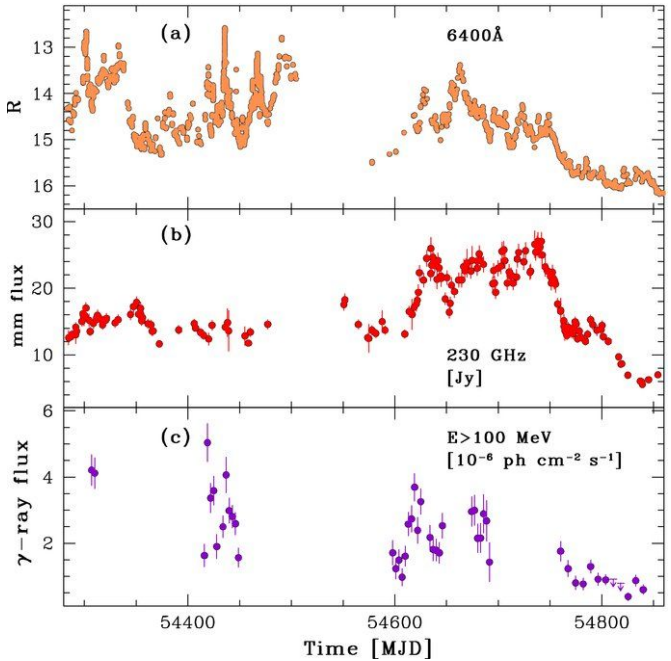


S4 0954+65, Raiteri et al. 2023, MNRAS, 526, 4502

Collaborations with other teams: AGILE

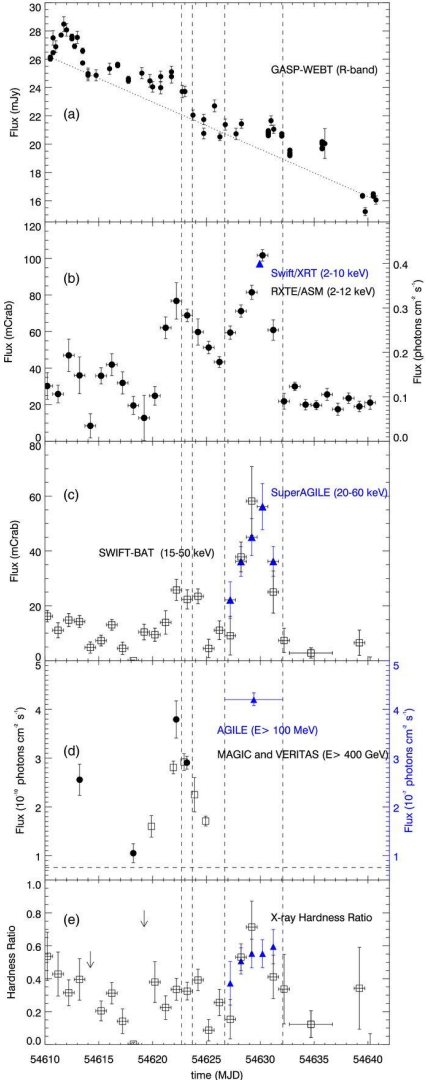


3C 279, Pittori et al. 2018, ApJ, 856,99

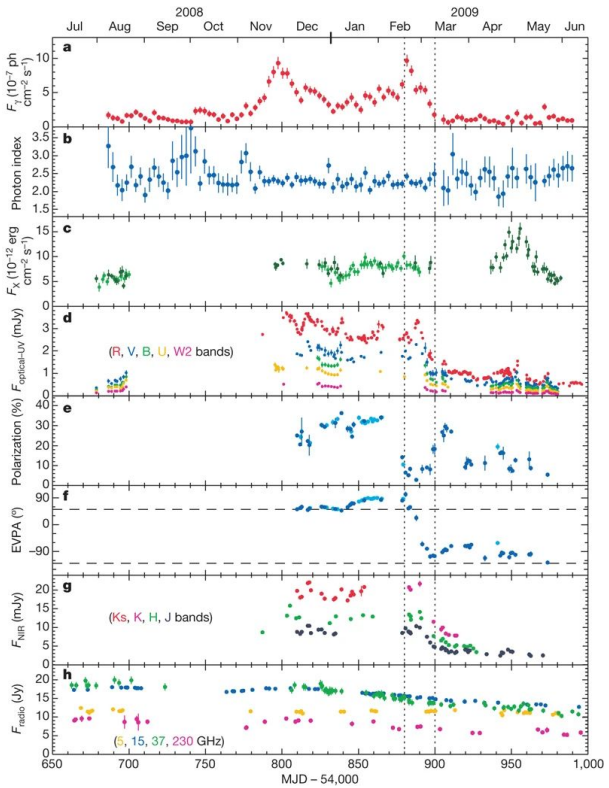


3C 454.3 "The Crazy Diamond"
Vercellone et al. 2010, ApJ, 712, 405

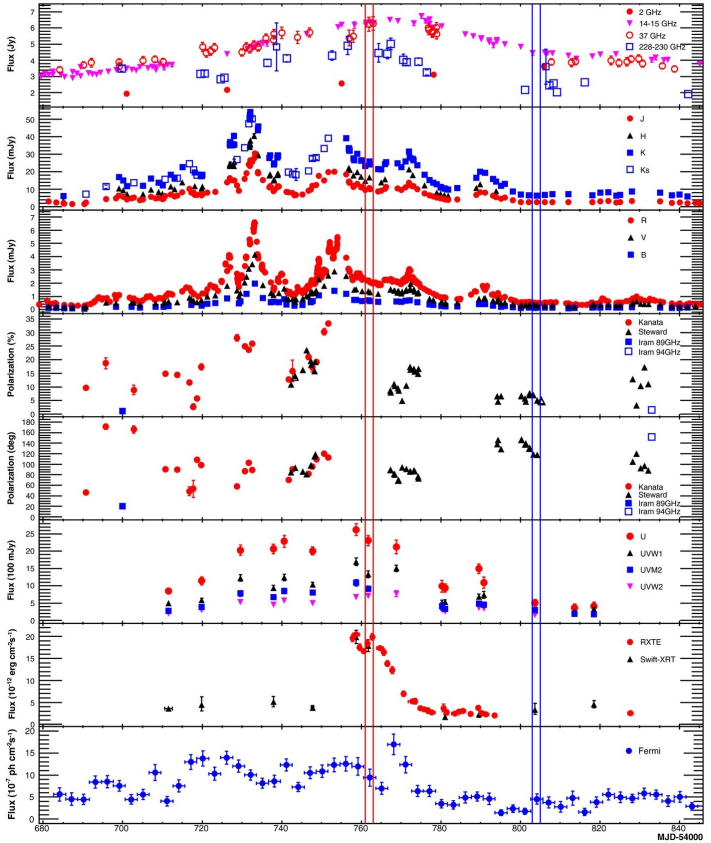
Mkn 421, Donnarumma et al. 2009, ApJ, 691:L13



Collaborations with other teams: Fermi

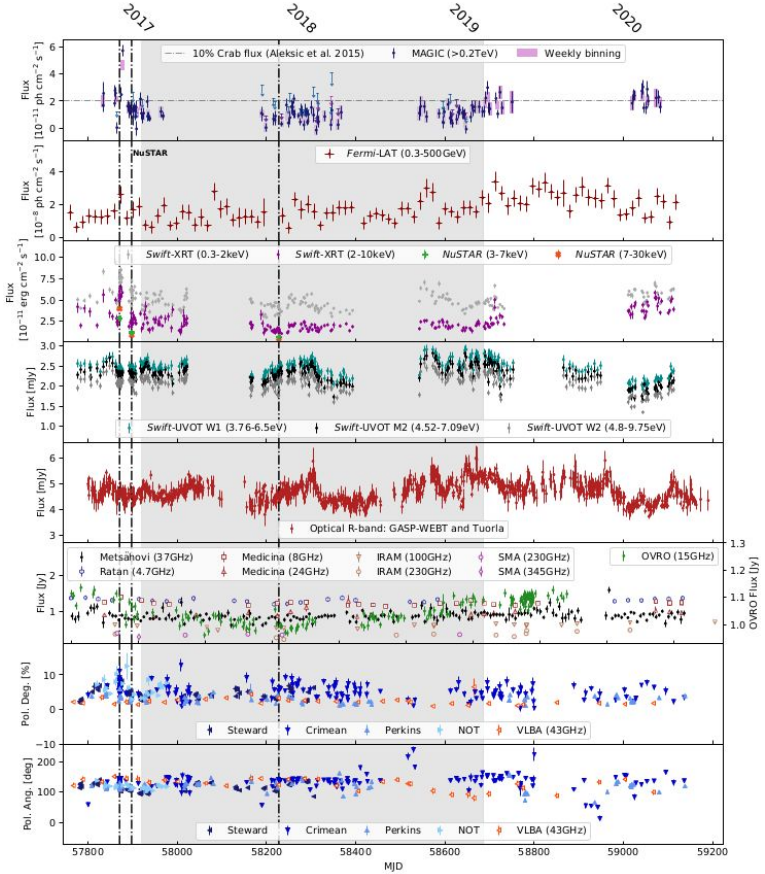


3C 279, Abdo et al. 2010, Nature, 463, 919

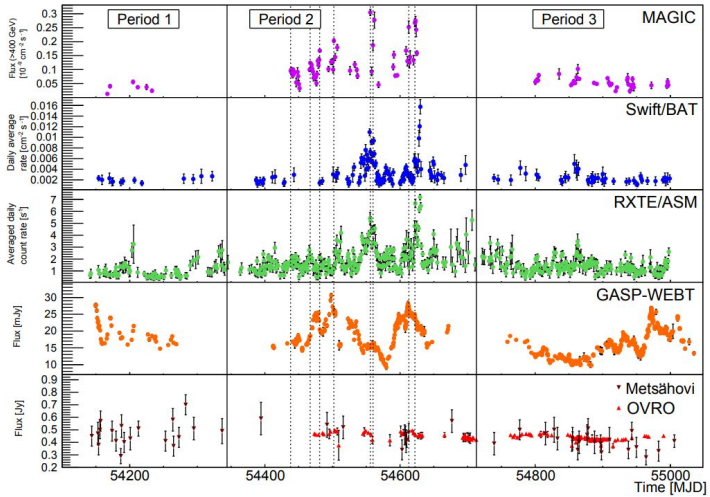


AO 0235+16, Ackermann et al 2012 ApJ 751 159

Collaborations with other teams: MAGIC



Mrk 501, Abe et al., 2023, ApJS, 266,37



Mkn 421, Ahnen et al. 2016, A&A 593, A91

Common projects on:

S5 0716+714
Mkn 421
Ton 599
PG 1553+113
Mkn 501
BL Lacertae
1ES 2344+514

We are looking forward to collaborating on LST and CTA projects!

Thank you for your attention!