Multiwavelength observations in 2019-2020 of a new very-high-energy gamma-ray emitter: the flat spectrum radio quasar QSO B1420+326

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MAGIC telescopes

- Two 17-m diameter telescopes located at La Palma, Spain
- Energy range: from a few tens of GeV to a few tens of TeV
- Sensitivity in the best energy range ~0.7 % of the Crab Nebula flux in 50 hr

Large collection area and low energy threshold make MAGIC a perfect follow-up instrument for Fermi-LAT alerts of (distant) blazars

QSO B1420+326 (a.k.a. OQ 334)

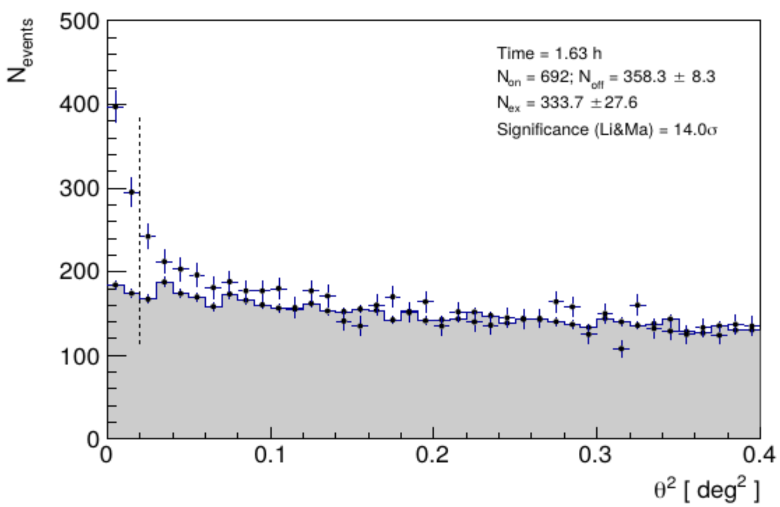
- FSRQ located at redshift of 0.682
- Strongly variable in gamma rays
- Recent flaring activity started in December 2019. Follow-up observations with the MAGIC telescopes during an organized MWL campaign resulted in adding this source to the rare family of VHE-detected FSRQs.

Fermi LAT detection of renewed GeV gamma-ray flaring activity from OQ 334 (B2 1420+32)

ATel #13382; ***S. Ciprini (1. INFN Tor Vergata, Rome; 2. ASI Space Science Data Center, Rome), C. C. Cheung (U. S. Naval Research Laboratory, Washington), on behalf of the Fermi Large Area Telescope Collaboration***
on ***1 Jan 2020; 20:15 UT***
Credential Certification: Stefano Ciprini (stefano.ciprini@ssdc.asi.it)

Detection of very-high-energy gamma-ray emission from B2 1420+32 with the MAGIC telescopes

ATel #13412; ***Razmik Mirzoyan (Max-Planck-Institute for Physics, Munich), on behalf of the MAGIC collaboration***
on ***21 Jan 2020; 21:03 UT***
Distributed as an Instant Email Notice Transients
Credential Certification: Giacomo Bonnoli (giacomo.bonnoli@unisi.it)



Acciari et al. 2021, A&A, 647, A163

Rich MWL campaign

- Flux measurements in radio, NIR, optical, UV, X-ray, HE and VHE gamma rays
- Optical polarimetry
- Optical spectroscopy
- Follow-up with radio interferometry

4 periods selected for detailed analysis:

Period	MJD	comment
A	58846.5 - 58853.5	pre-flare
B	58867 - 58868	optical flare
C	58868.3 - 58870.3	VHE flare
D	58873.5 - 58880.5	post-flare

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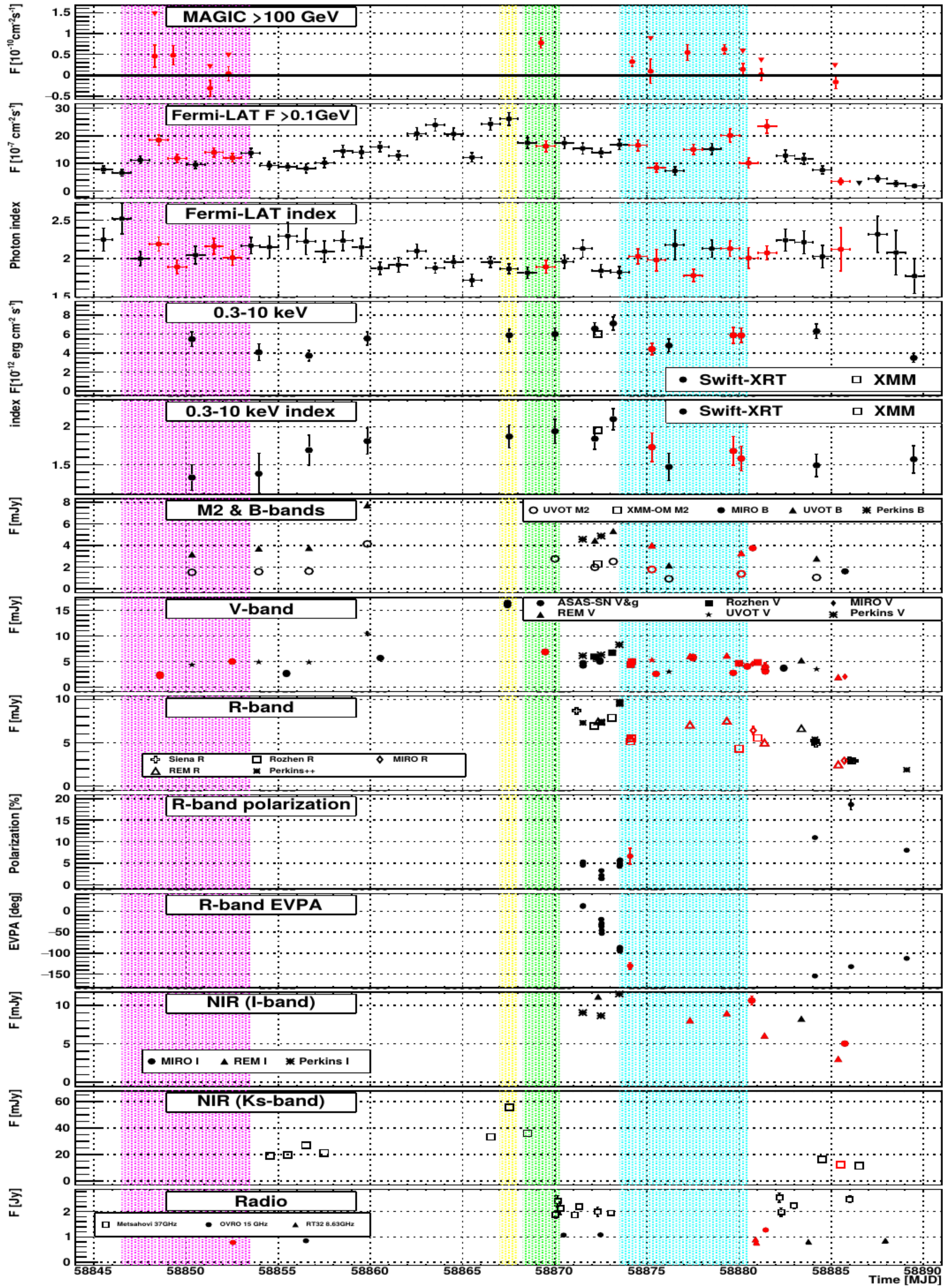
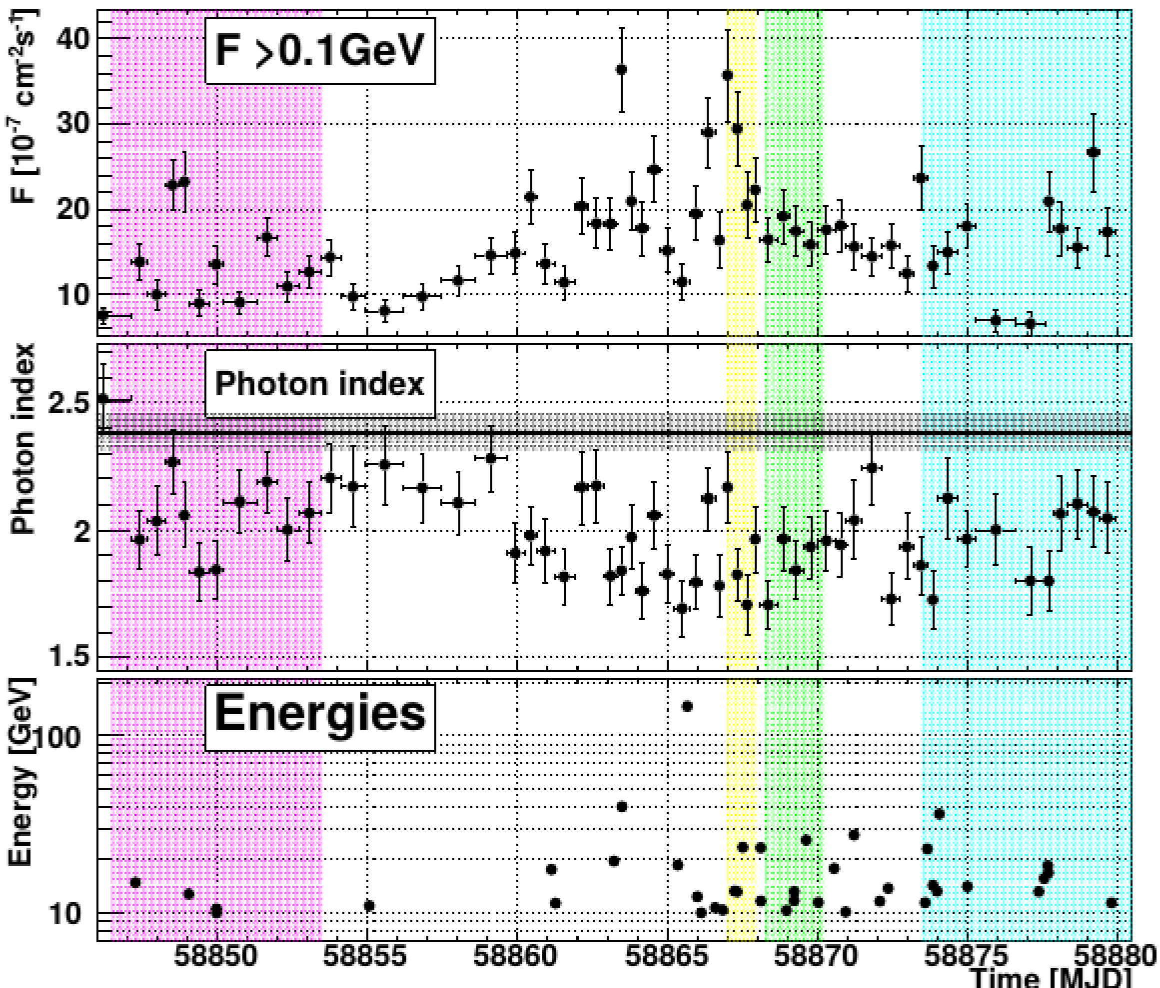


Fermi-LAT view

- Adaptive binning down to time scales of ~6 hrs
- The flux reached 400 times the 4FGL value
- Evolution of the spectral index
- The highest energy photon of 150 GeV



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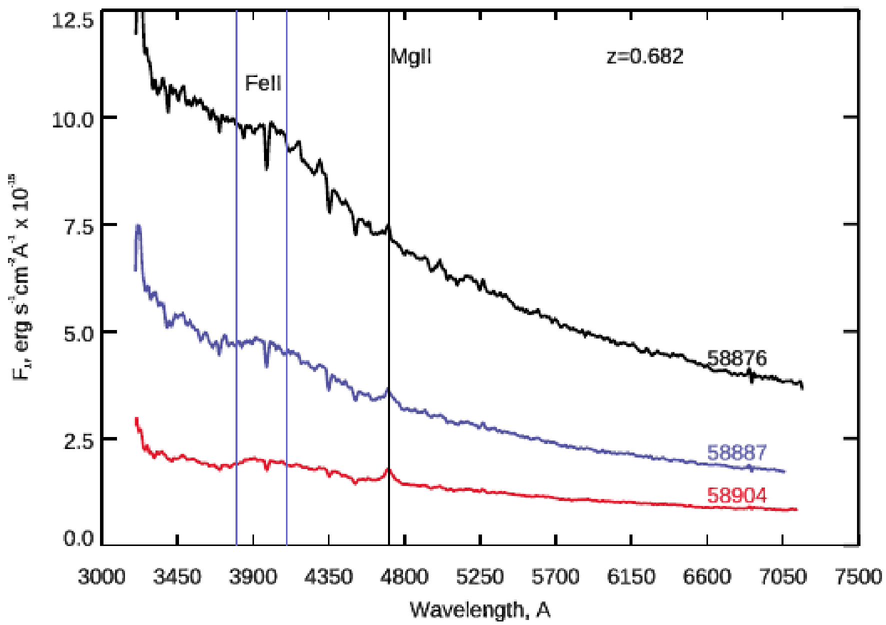
Follow-up spectroscopy

- MgII line: constant flux. Excited by underlying thermal accretion disk continuum.
- As the flux evolves EW increases from 2Å (BL Lac-like) to 11Å (FSRQ-like)
- Estimated accretion disk luminosity of L_{AD} = 2x10^{46} erg s^{-1}



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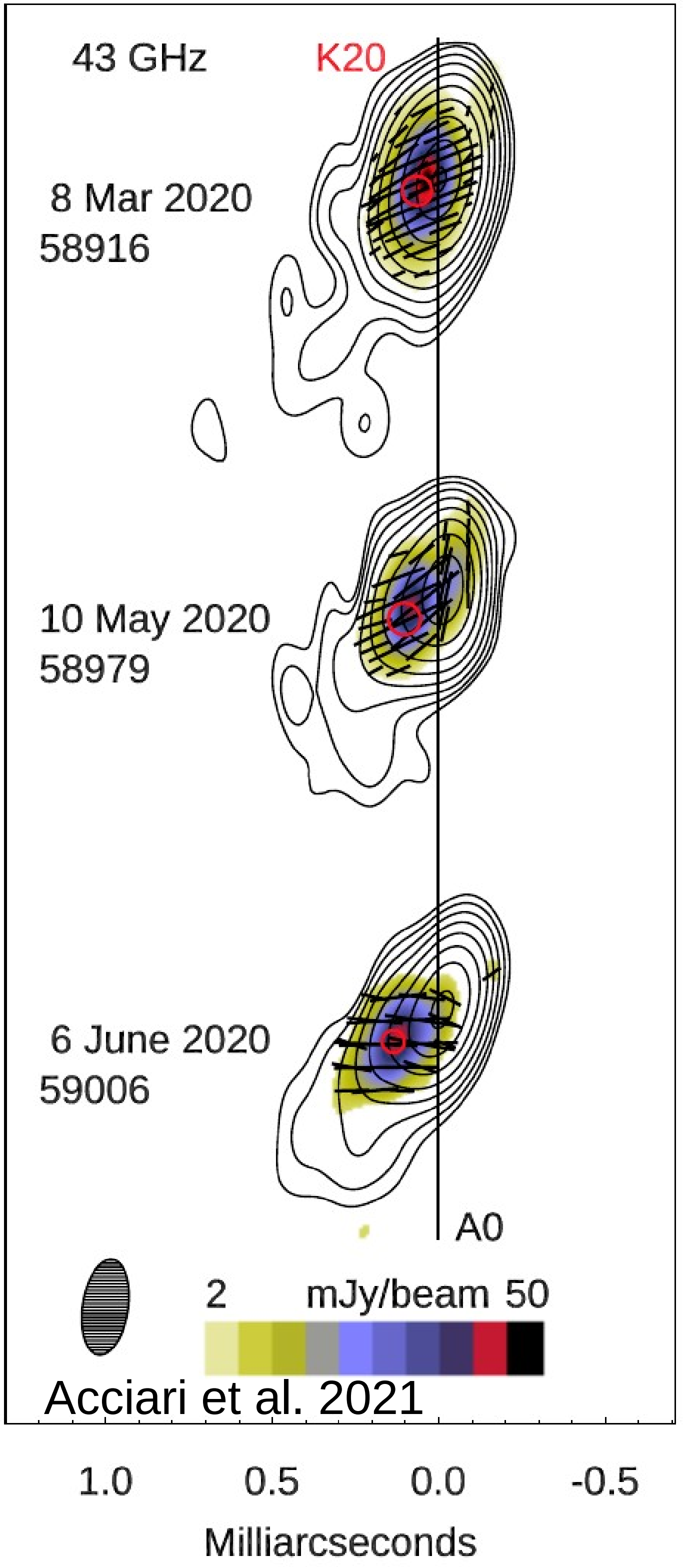
- FeII bump: flux correlated with continuum level. Possibly an interaction of non-thermal jet with FeII-emitting cloud

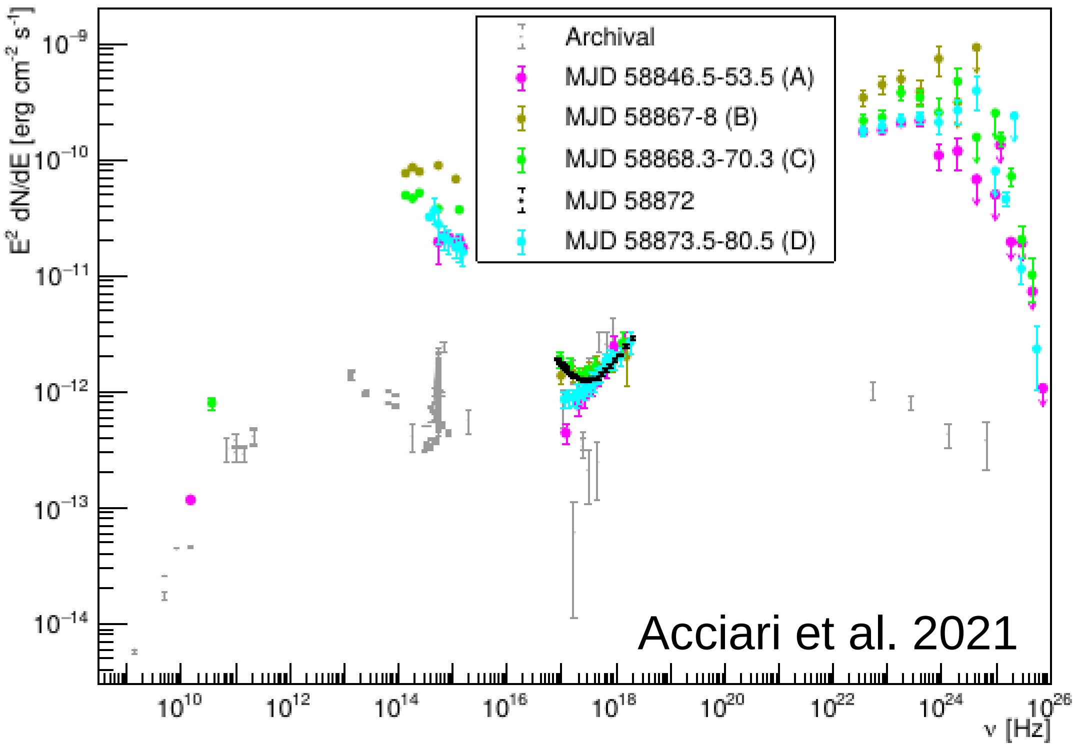
VLBA images

- Follow-up radio interferometry measurements shown a new knot (K20) ejected from the core with Γ=19±9 and δ=33±9
- During the time of VHE emission the upstream edge of the knot was passing through the centroid of the core



SED evolution

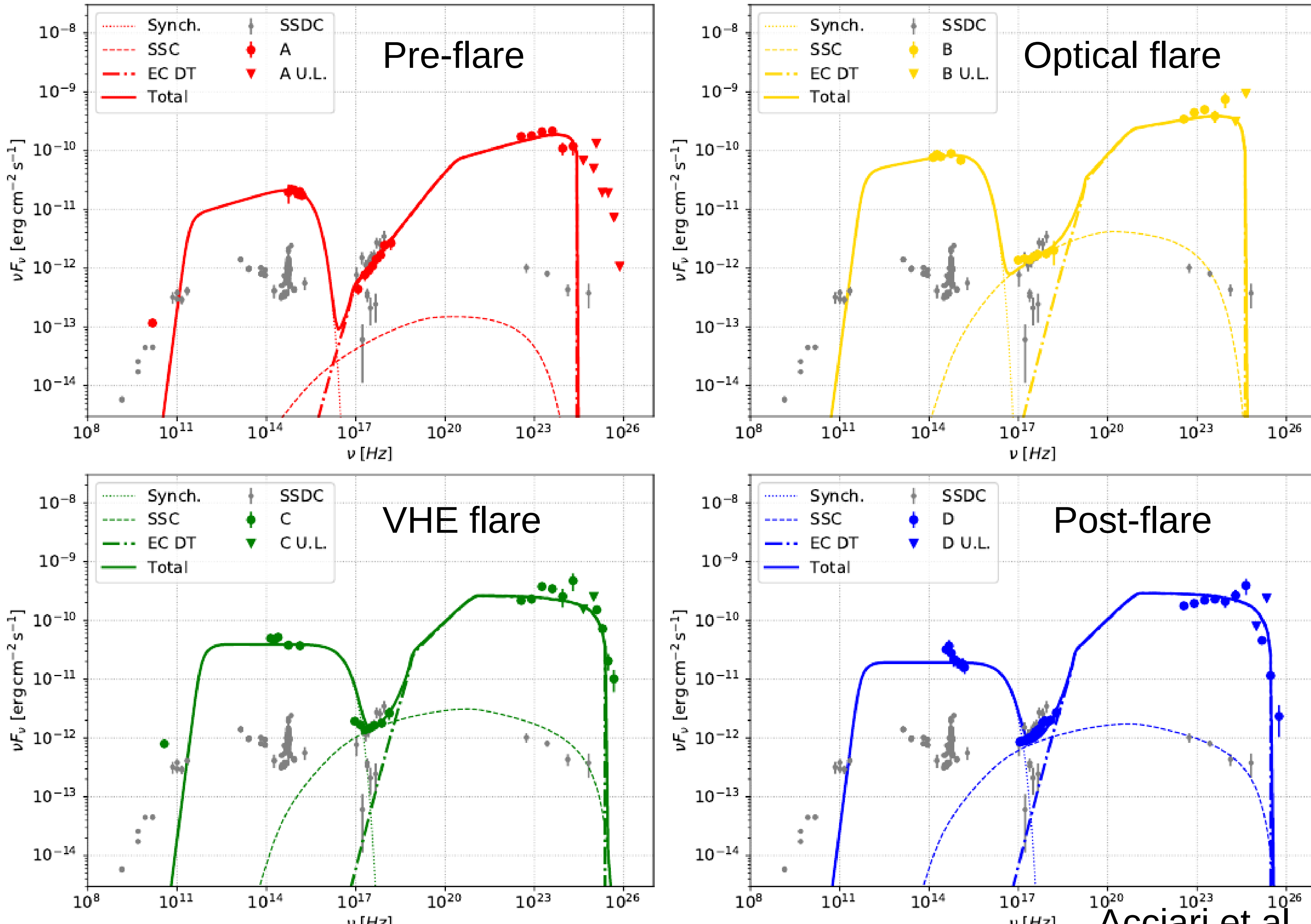
- Flux of both SED peaks are over two orders of magnitude above the historical measurement
- Evolution of the shape of the peaks throughout the campaign – flat optical spectrum during the peak of the flare
- X-ray measurements show the transition between synchrotron and IC peak



Modeling scenario and constraints

- FSRQ ==> likely External Compton – radiation fields computed from the estimated accretion disk luminosity
- Large increase of optical flux ==> SSC component
- Size of the emission region r_b ==> limited by ~1 day time scale variability
- Speed of the jet assumed $\Gamma=\delta=40$ (roughly inspired by VLBA measurements, which however probe jet at much larger distance)
- VHE gamma-rays ==> emission region beyond BLR, assumed the $d \sim \Gamma\ r_b$ – in the dust torus radiation field
- Electron energy distribution determined by balance of the cooling, acceleration and dynamic time scale
- Modeling performed with `agnpy` (https://agnpy.readthedocs.io) code, each period modeled independently

SED modeling



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Scenario from the modeling

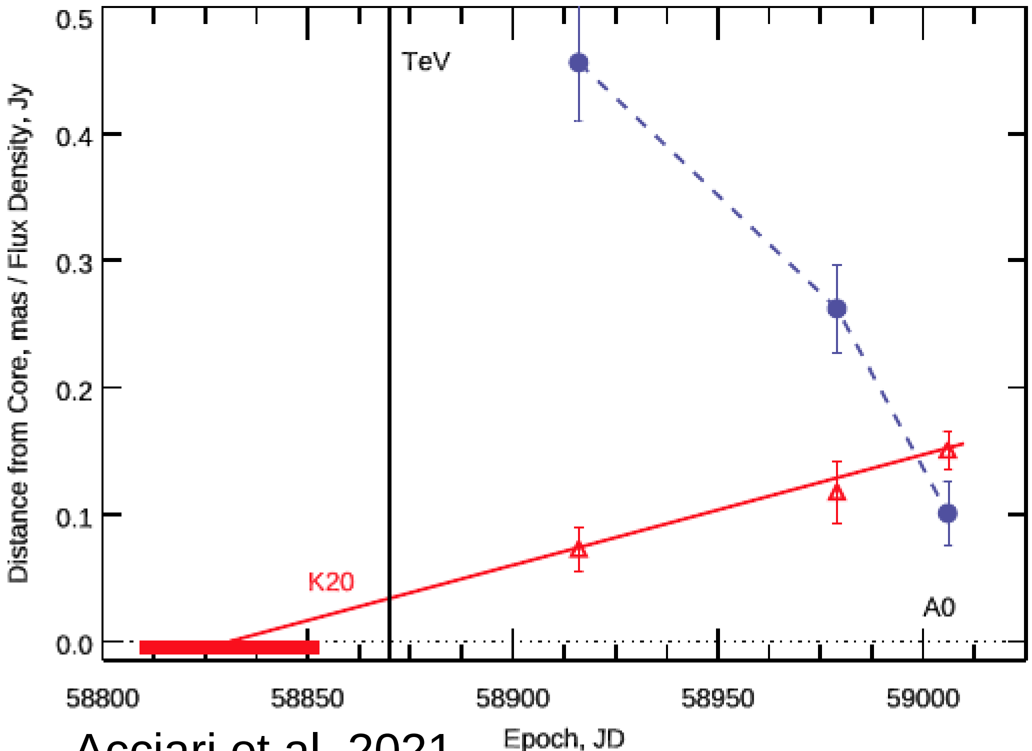
- Gamma rays explained as EC emission on DT radiation field
- (highly variable in shape) X-ray emission explained as a combination of falling edge of synchrotron, bulk of SSC and raising edge of EC emission
- Proposed solution is close to u_e/u_B equipartition (0.06 – 1.6)

Summary

- QSO B1420+326 is a new member of VHE-emitting FSRQ family
- Rich MWL campaign that allowed us to track and model the evolution of broadband emission
- Emission of new radio knot and rotation of optical EVPA closeby in time to VHE emission – similar cases were reported also for other VHE gamma ray FSRQs
- SED explained in EC(+SSC) scenario on DT photons with electron energy distribution limited by an interplay of acceleration, dynamic and cooling time scales

Backup

K20 separation



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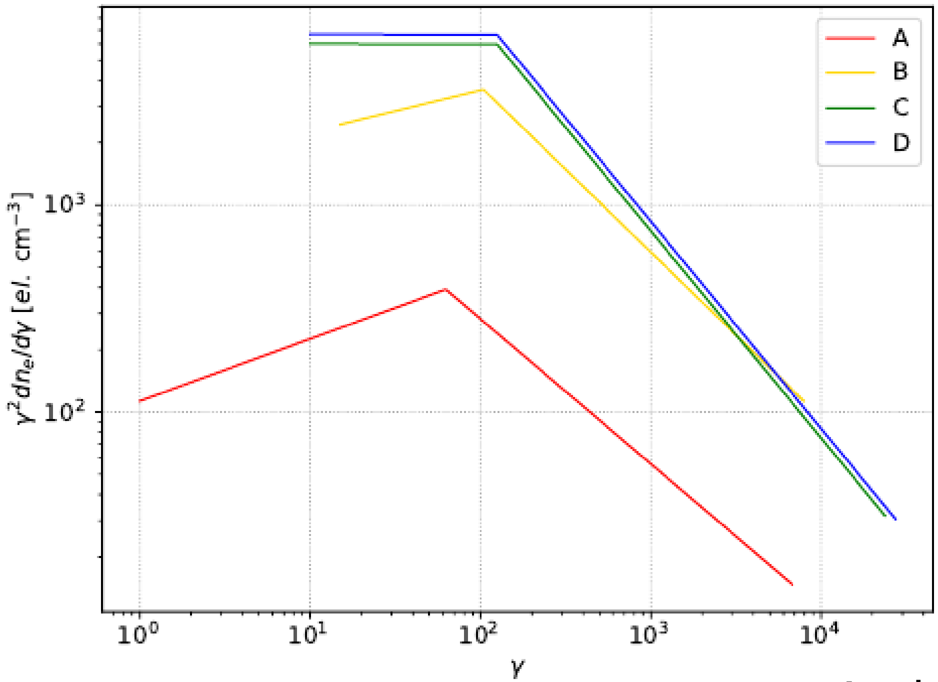
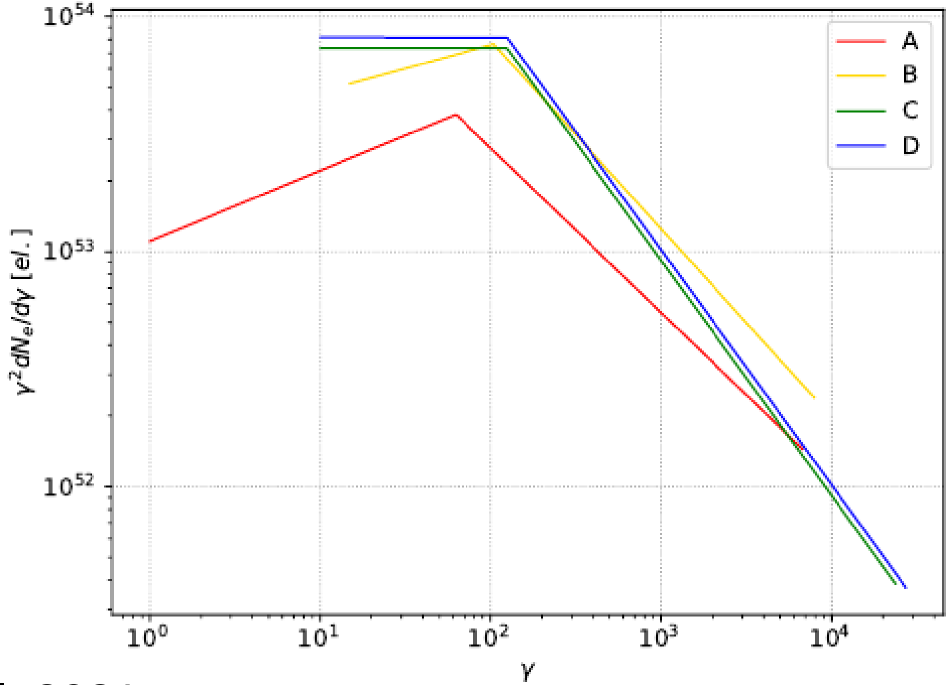
Modeling parameters





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Period	δ	r_b [cm]	ξ	B [G]	$U'_e[10^{48}\text{erg}]$	p_1	$\gamma_{\min}$	p_2	γ_{break}	$\gamma_{\max}$	$u'_e[\text{erg cm}^{-3}]$	u'_e/u'_B
A	40	6.16×10^{16}	0.3×10^{-7}	0.70	1.18	1.7	1	2.7	63	6900	1.2×10^{-3}	0.06
B	40	3.70×10^{16}	0.3×10^{-7}	0.95	1.76	1.8	15	2.8	104	8000	8.3×10^{-3}	0.23
C	40	3.08×10^{16}	3.0×10^{-7}	0.83	2.12	2.0	10	3.0	125	23700	17.3×10^{-3}	0.63
D	40	3.08×10^{16}	6.0×10^{-7}	0.55	2.35	2.0	10	3.0	125	27300	19.2×10^{-3}	1.6

Table 6. Parameters used for the modeling: Doppler factor δ ($\Gamma = \delta$ is assumed), co-moving size of the emission region r_b, acceleration parameter ξ, magnetic field B, total energy of electron U'_e, EED: slope before the break: p_1, minimum Lorentz factor $\gamma_{\min}$, slope after the break p_2, the Lorentz factor of the break γ_{break}, maximum Lorentz factor $\gamma_{\max}$, electron energy density u'_e, energy equipartition u'_e/u'_B. Free parameters of the model and derived parameters are put on the left and right side of the double vertical line respectively