Uncovering extreme blazar flares at cosmic dawn

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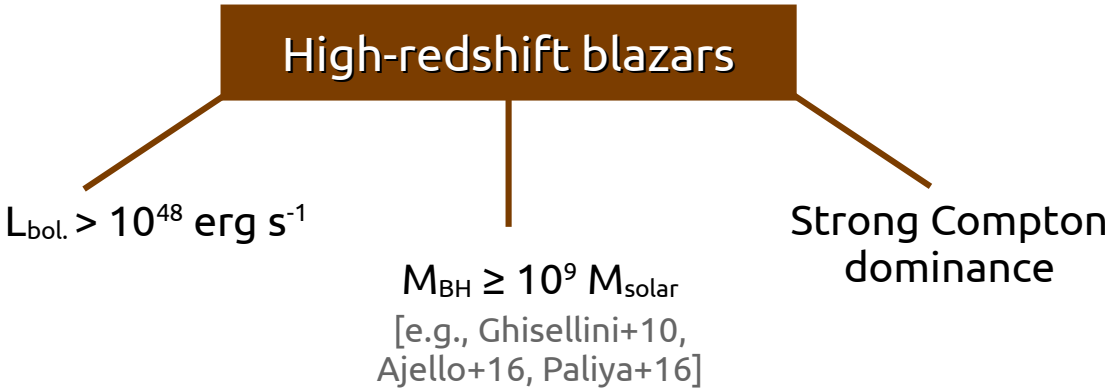
11th Fermi Symposium – September 2024

Image Credit: NASA/JPL-Caltech/GSFC

Why are high-redshift blazars interesting?



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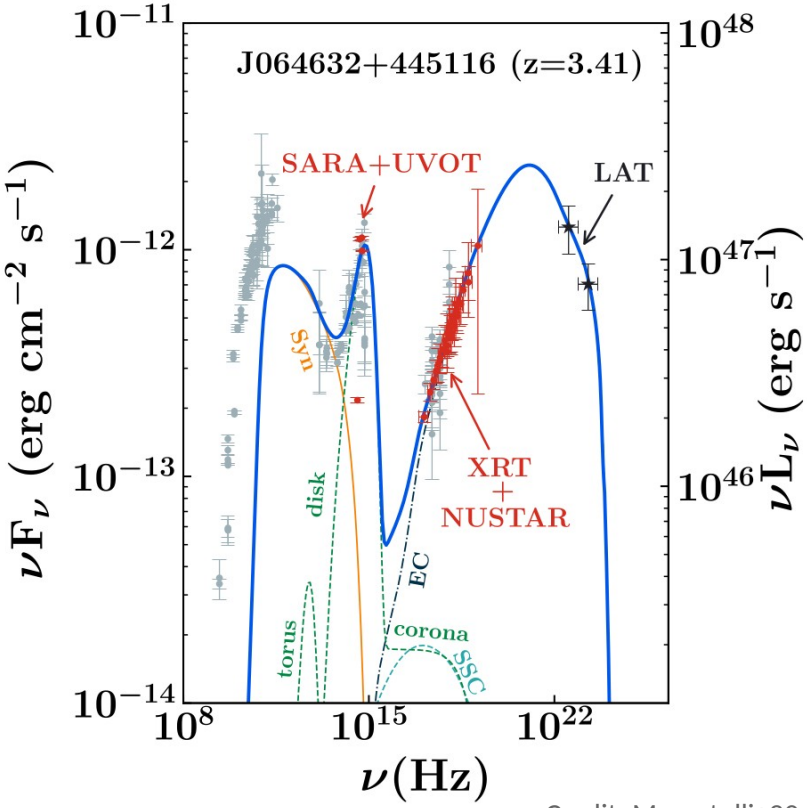
- $L_{bol.} > 10^{48}$ erg s^{-1}
- $M_{BH} \geq 10^{9}$ M_{solar} [e.g., Ghisellini+10, Ajello+16, Paliya+16]
- Strong Compton dominance

- High-energy hump peaks in MeV band
  → simultaneous X-ray and gamma-ray data necessary



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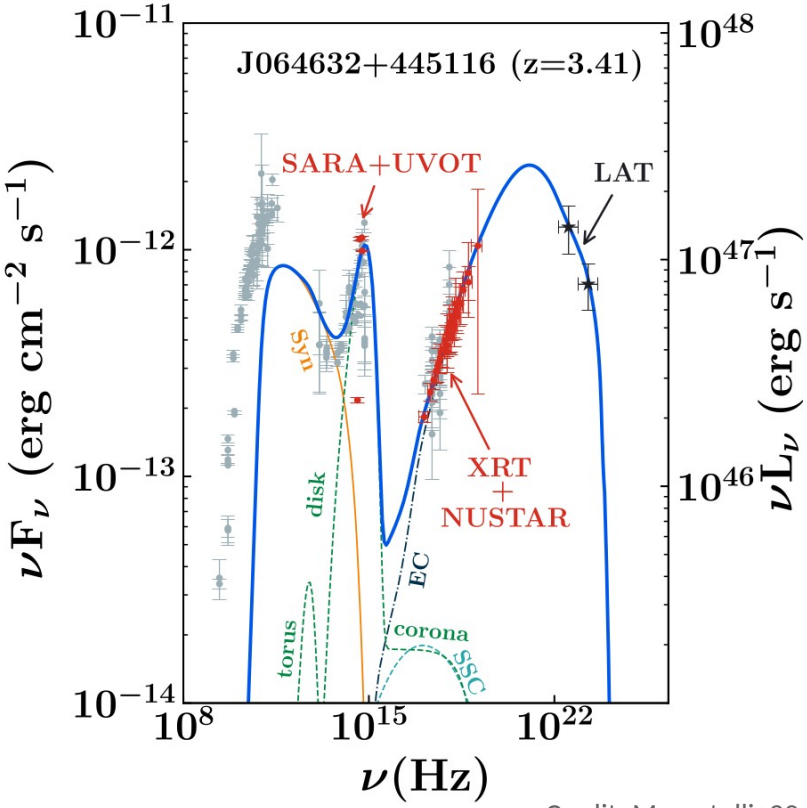

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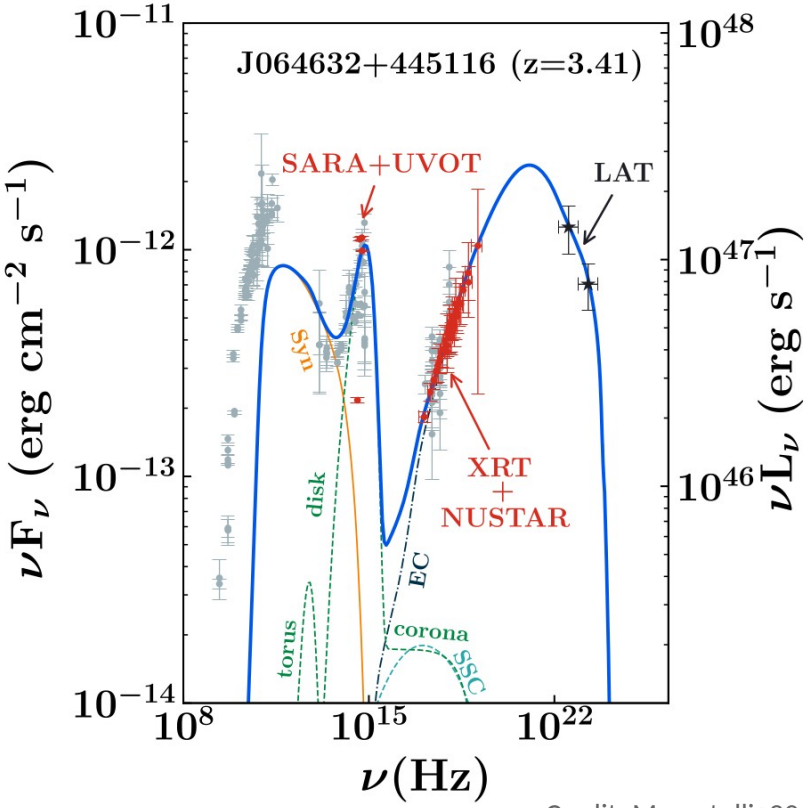

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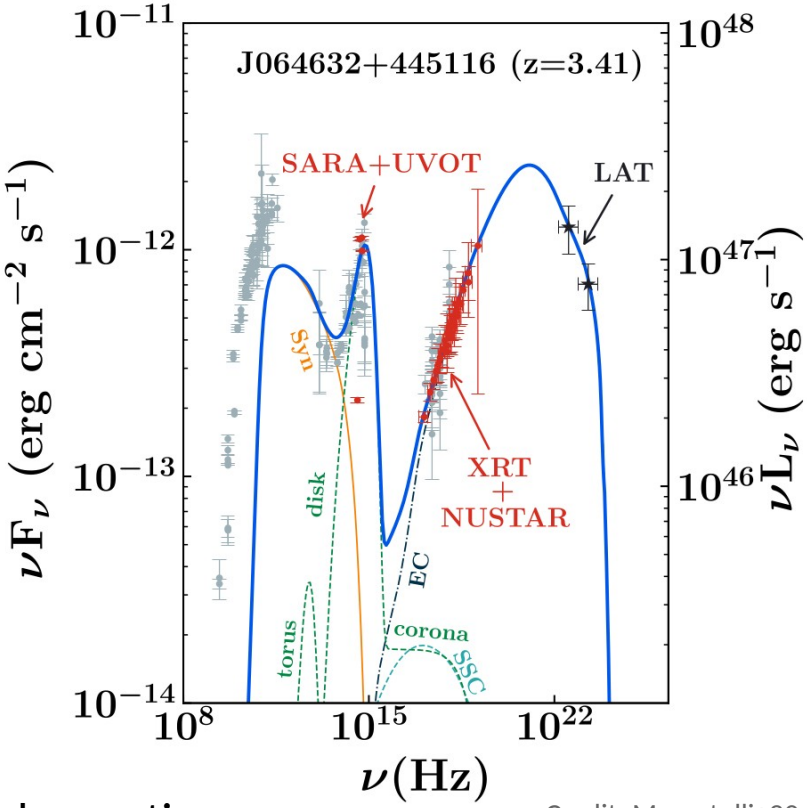

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- High redshift → probing regions closer to SMBH with radio observations

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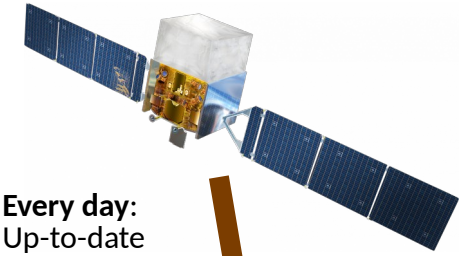

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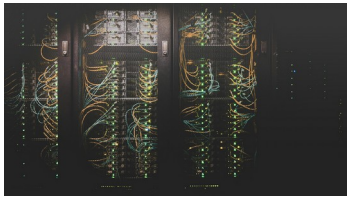

Automated pipeline looking for signal in the last 30 days at positions of high-*z* blazars

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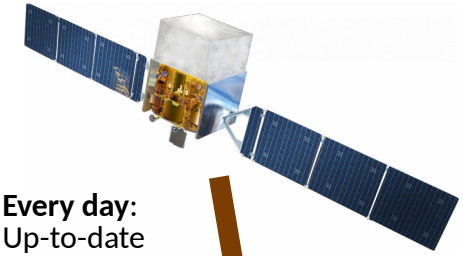

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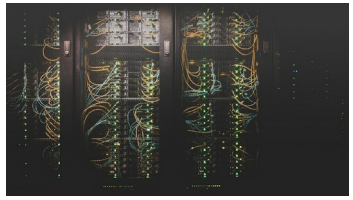

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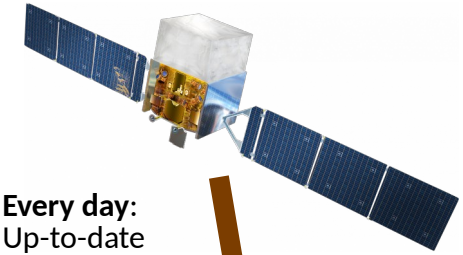

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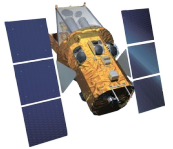
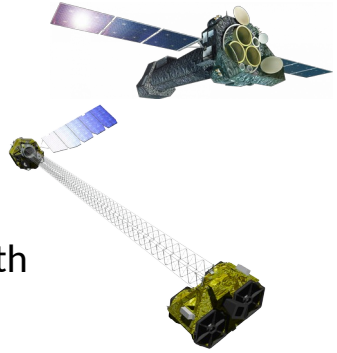
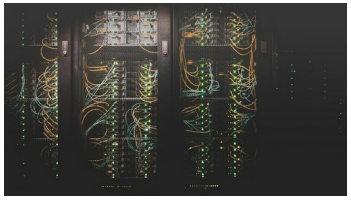




Multiwavelength campaign



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Flare of TXS 1508+572 ($z = 4.31$)

- Other source names:
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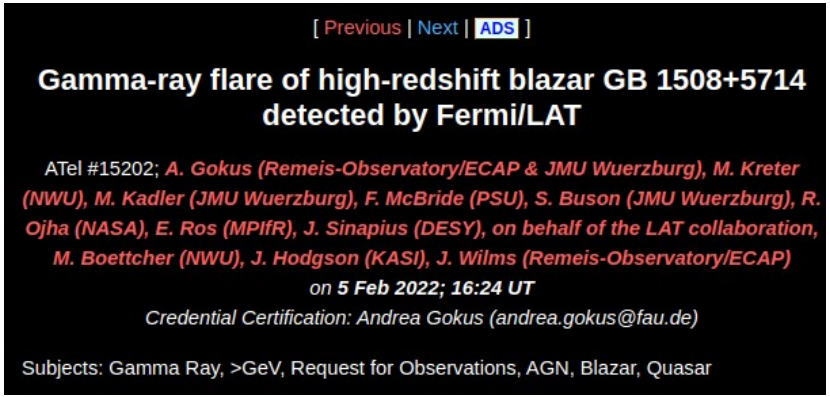

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Gamma-ray flare of high-redshift blazar GB 1508+5714 detected by Fermi/LAT

ATel #15202; *A. Gokus (Remeis-Observatory/ECAP & JMU Wuerzburg), M. Kreter (NWU), M. Kadler (JMU Wuerzburg), F. McBride (PSU), S. Buson (JMU Wuerzburg), R. Ojha (NASA), E. Ros (MPIfR), J. Sinapius (DESY), on behalf of the LAT collaboration, M. Boettcher (NWU), J. Hodgson (KASI), J. Wilms (Remeis-Observatory/ECAP)*
*on **5 Feb 2022; 16:24 UT***
Credential Certification: Andrea Gokus (andrea.gokus@fau.de)

Subjects: Gamma Ray, >GeV, Request for Observations, AGN, Blazar, Quasar

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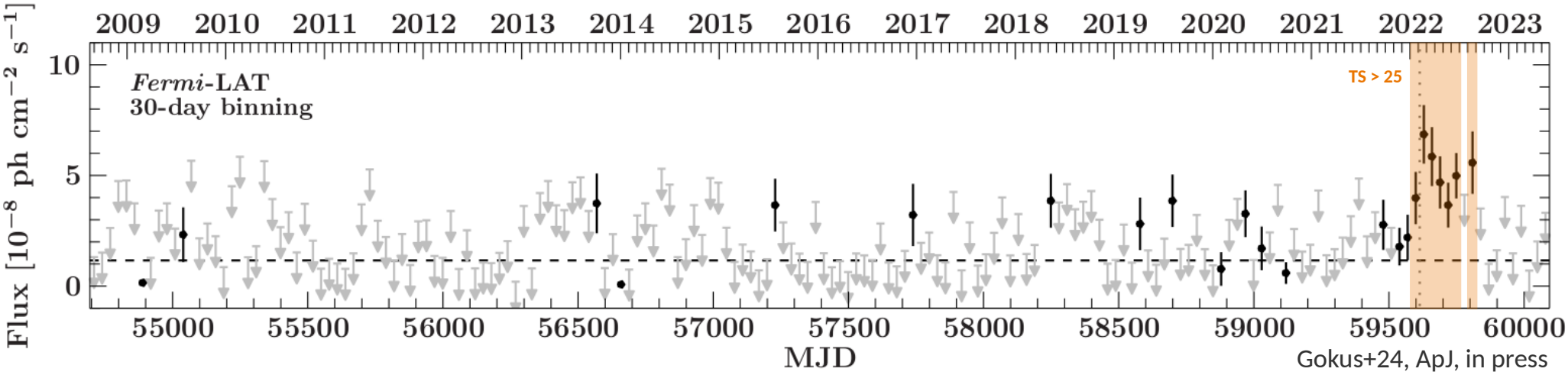
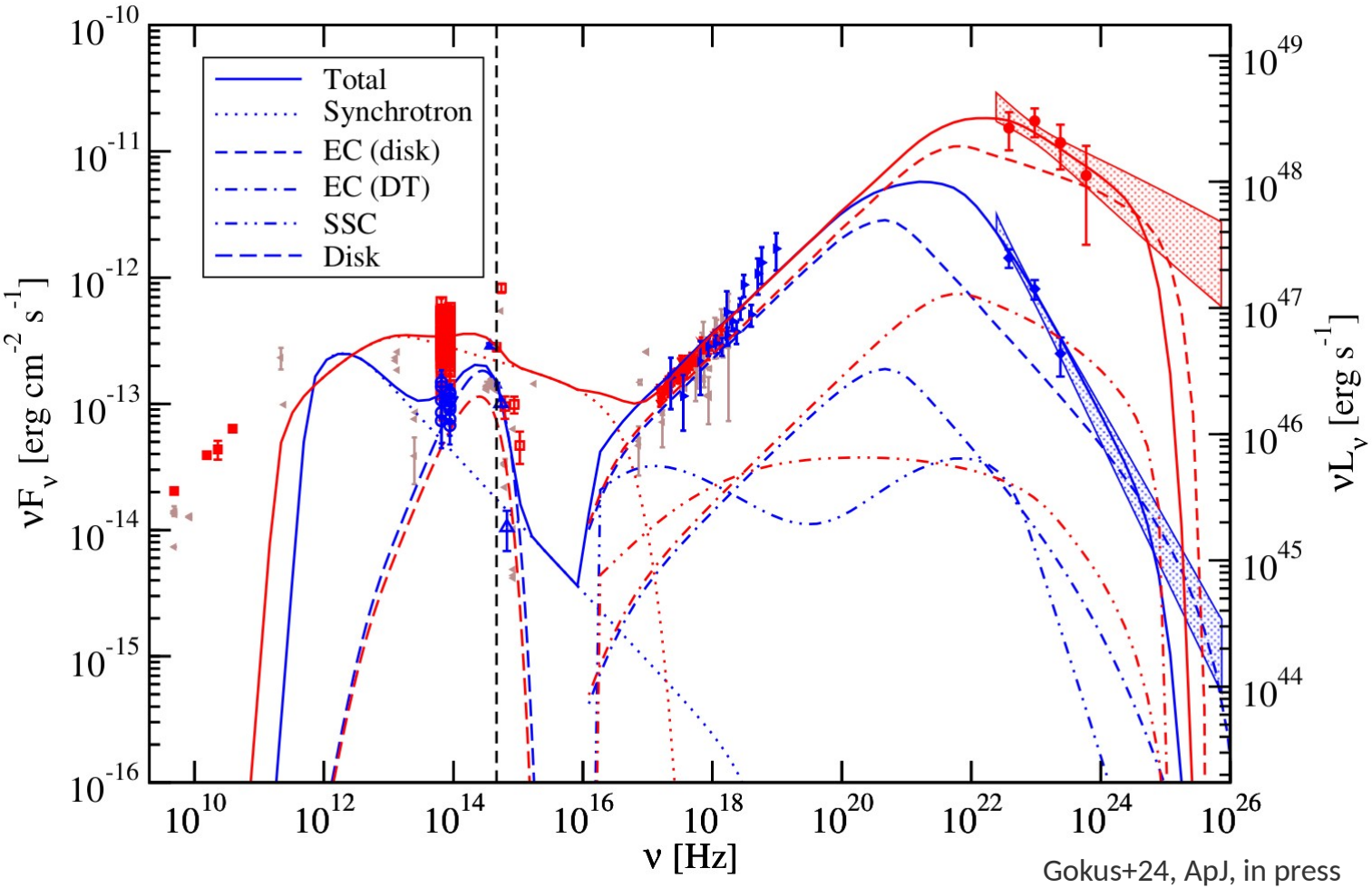
Long-term 30-day binned light curve (100 MeV – 300 GeV)
with upper limits for TS < 9:



Gokus+24, ApJ, in press

Broadband SED of TXS 1508+572

Quiescent state: **blue**
Flaring state: **red**



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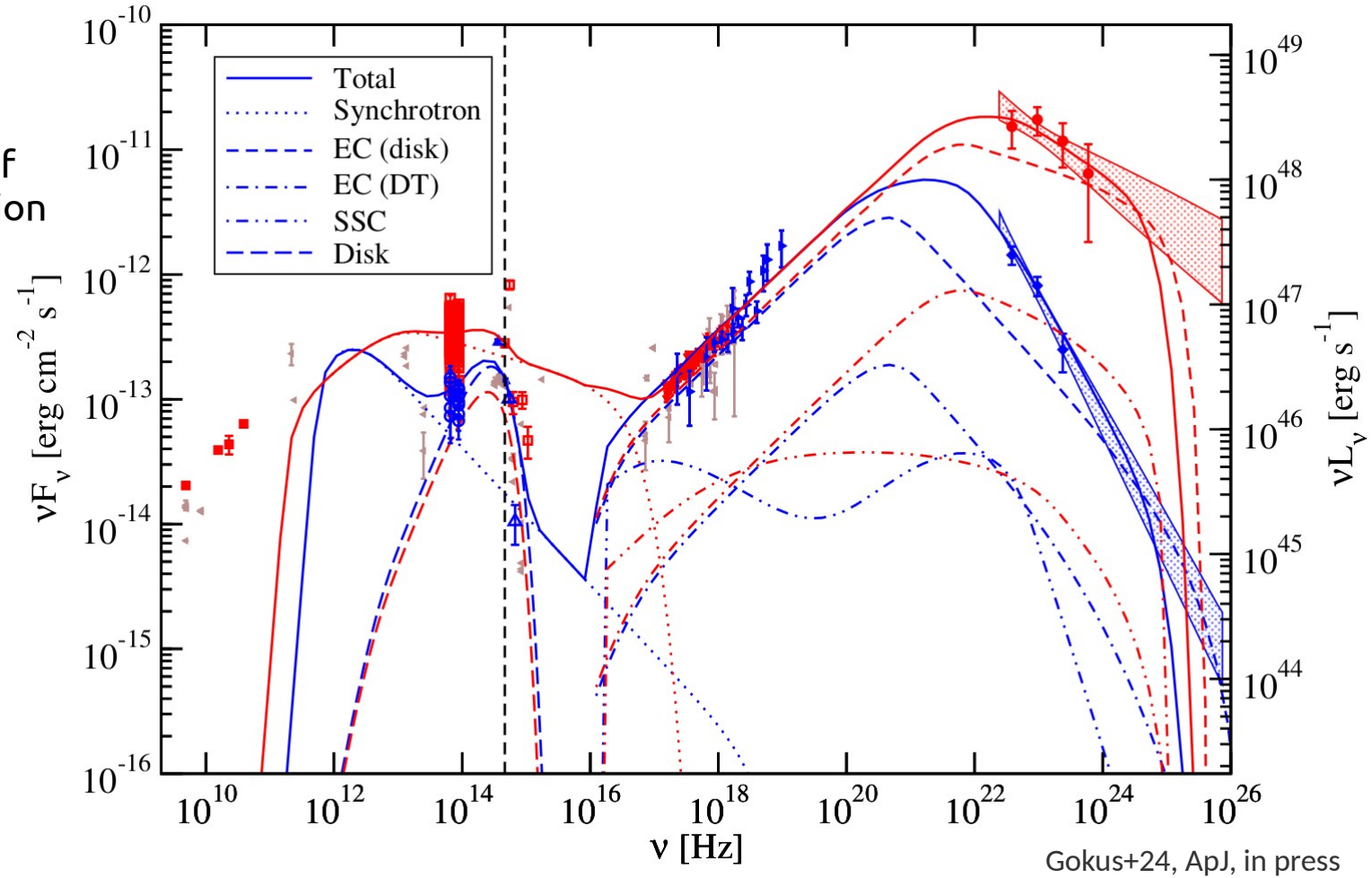

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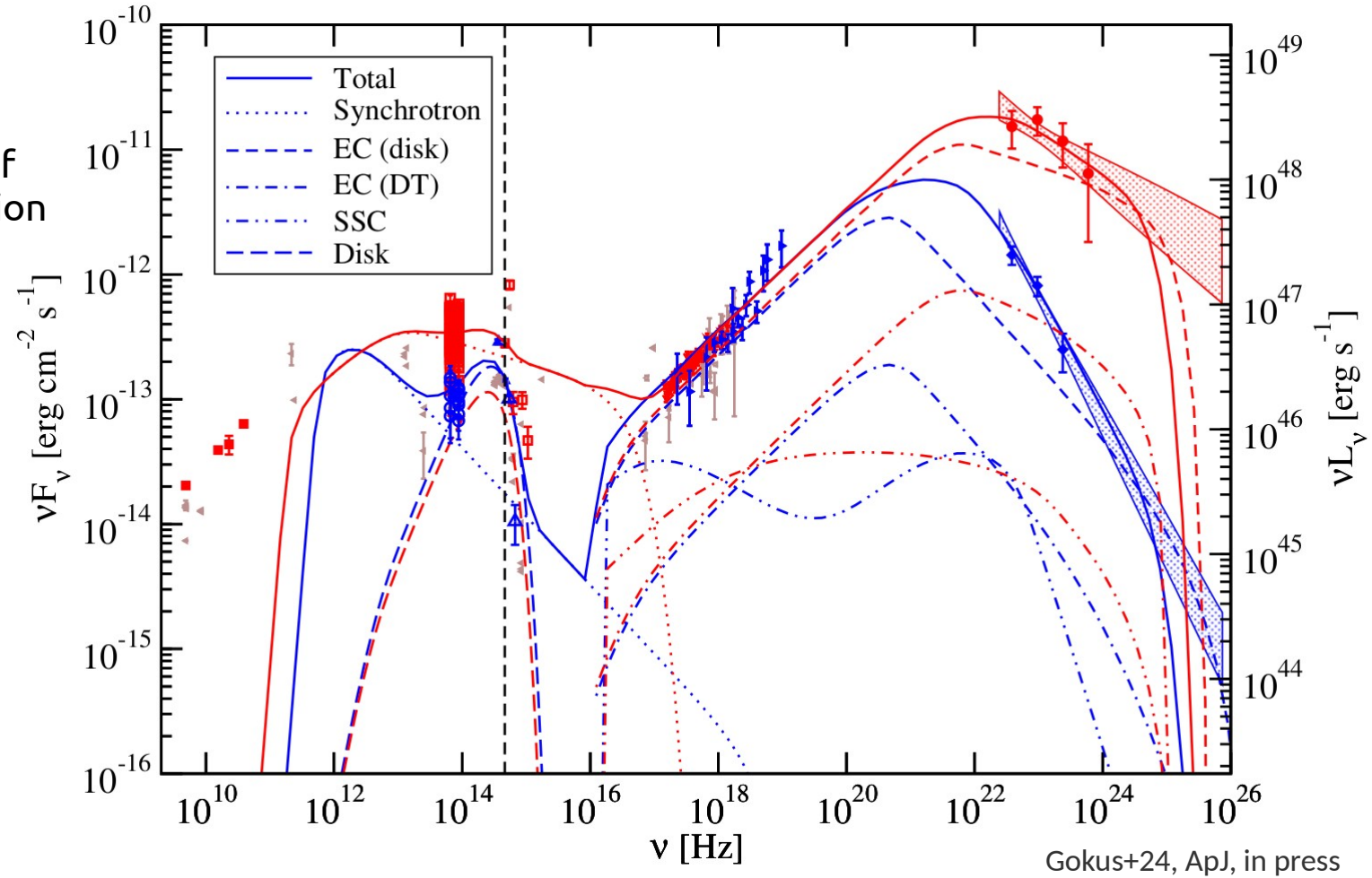

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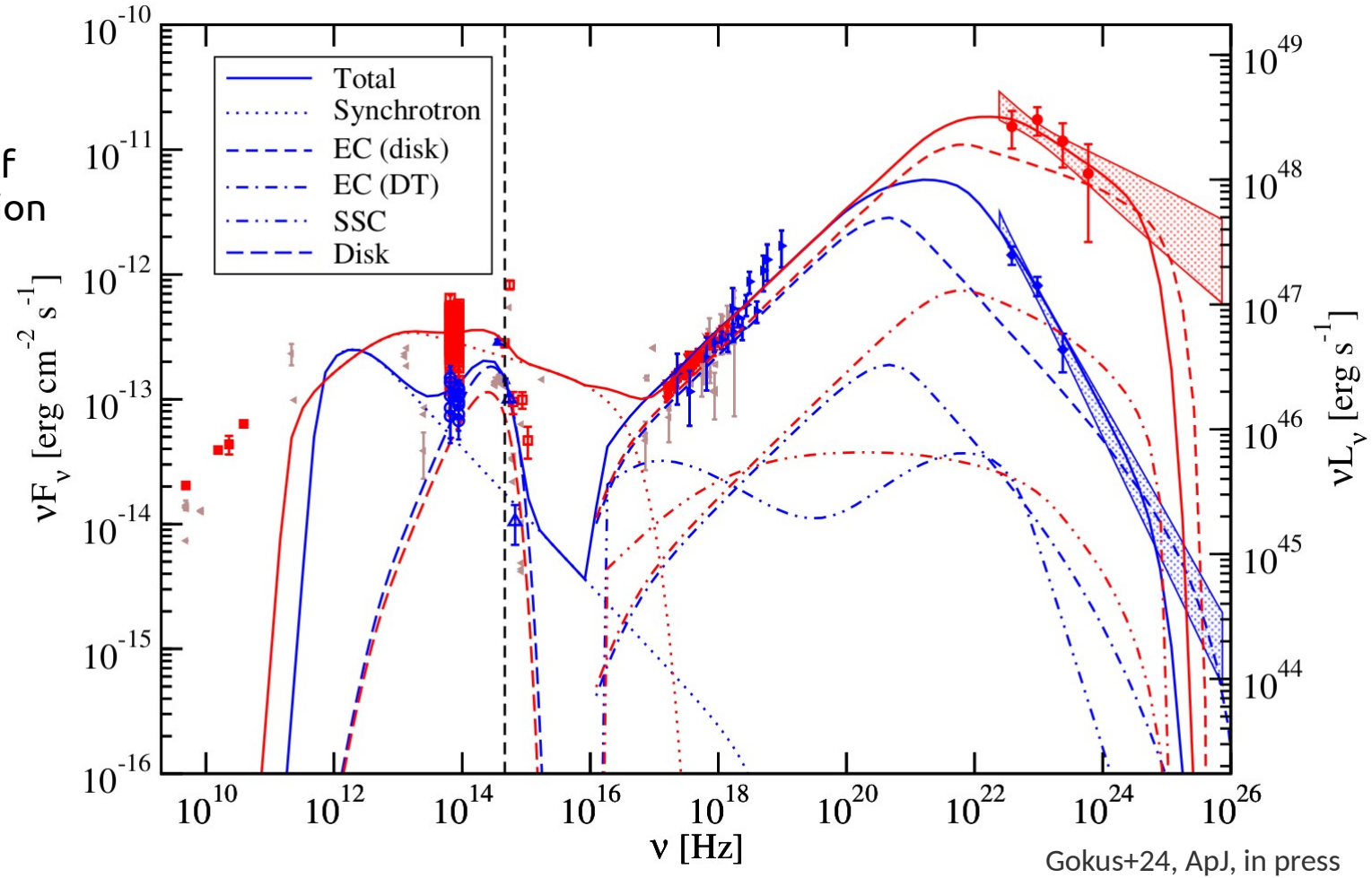

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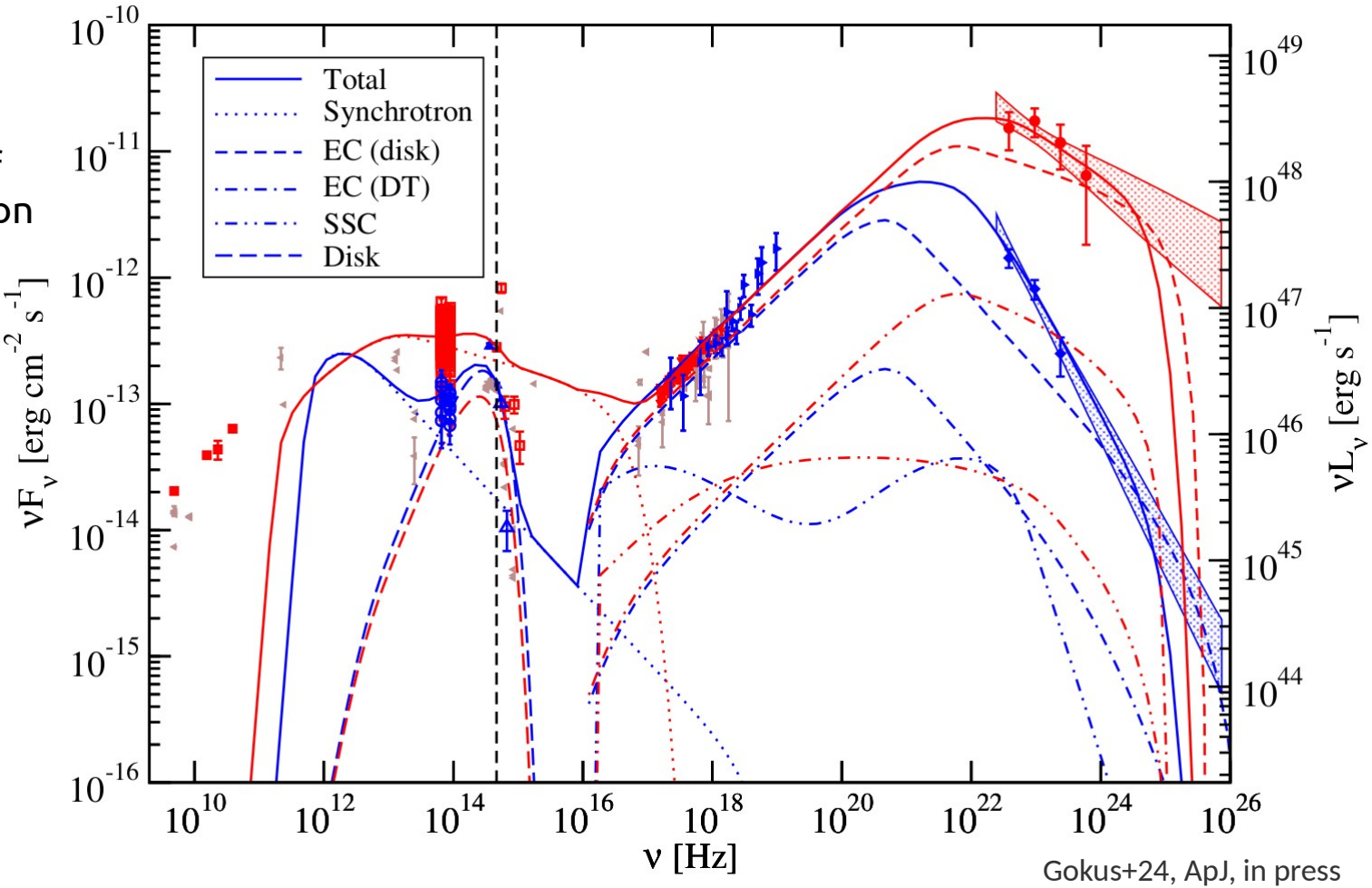

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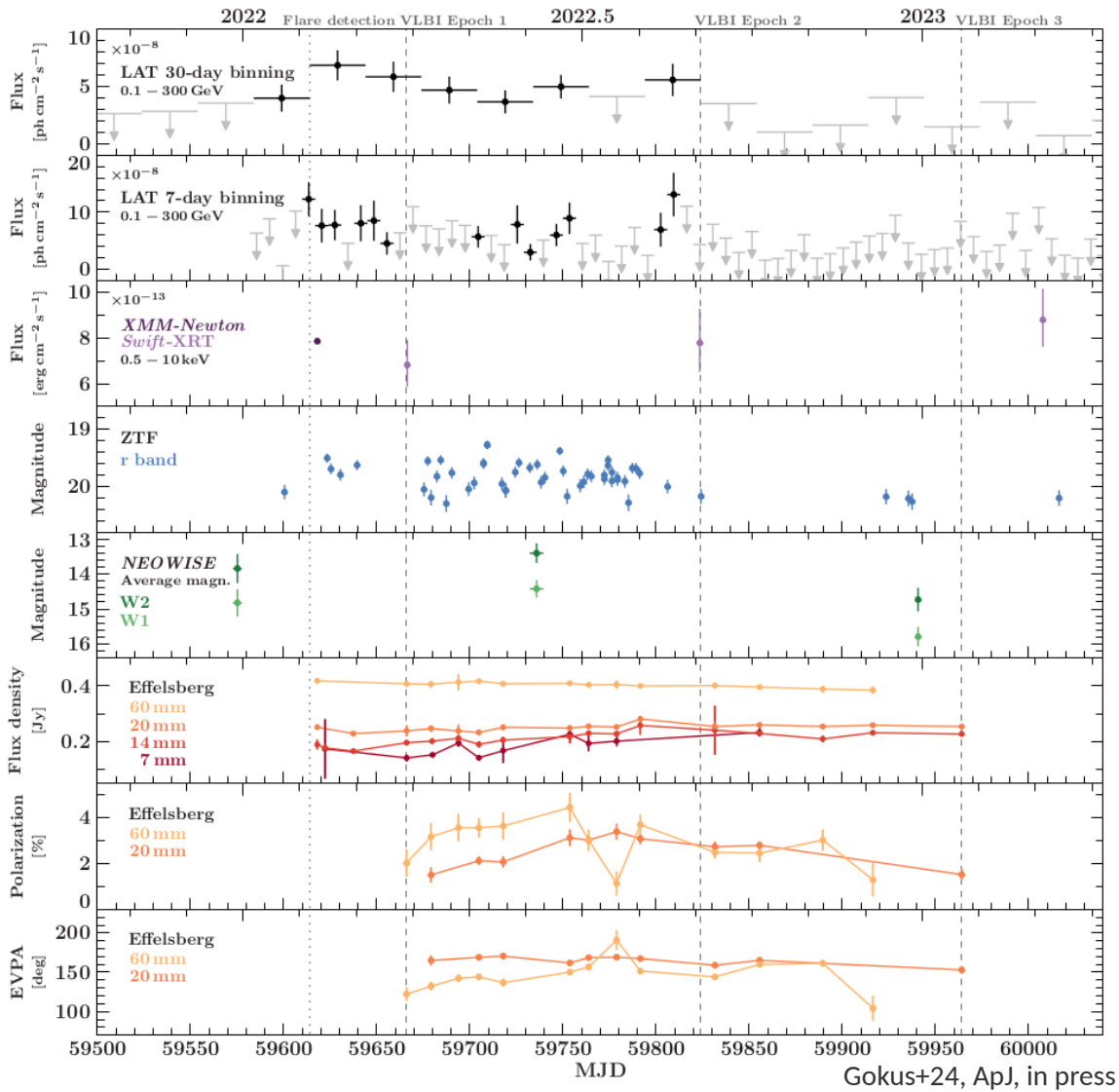
Variability of TXS 1508+572



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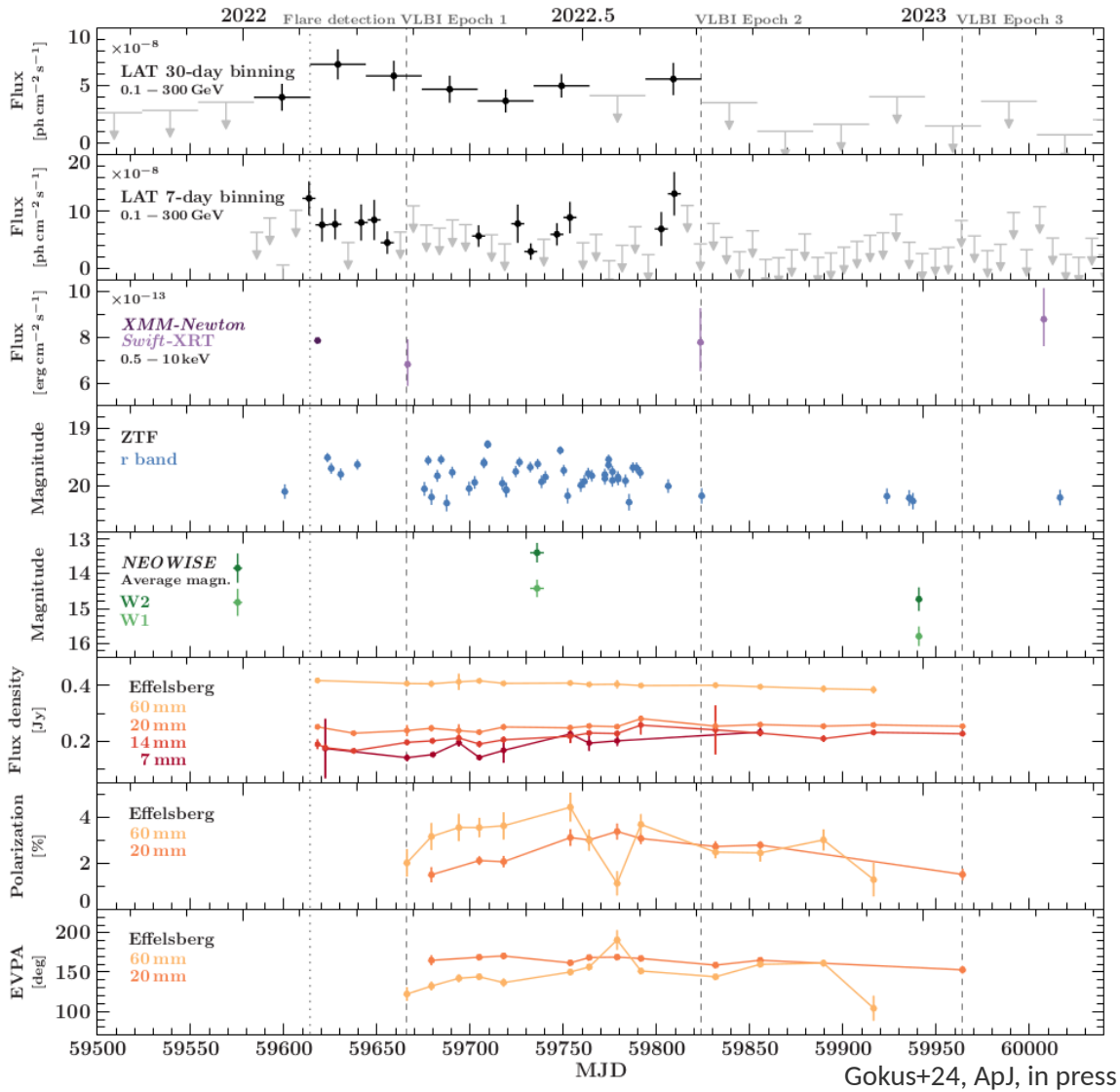

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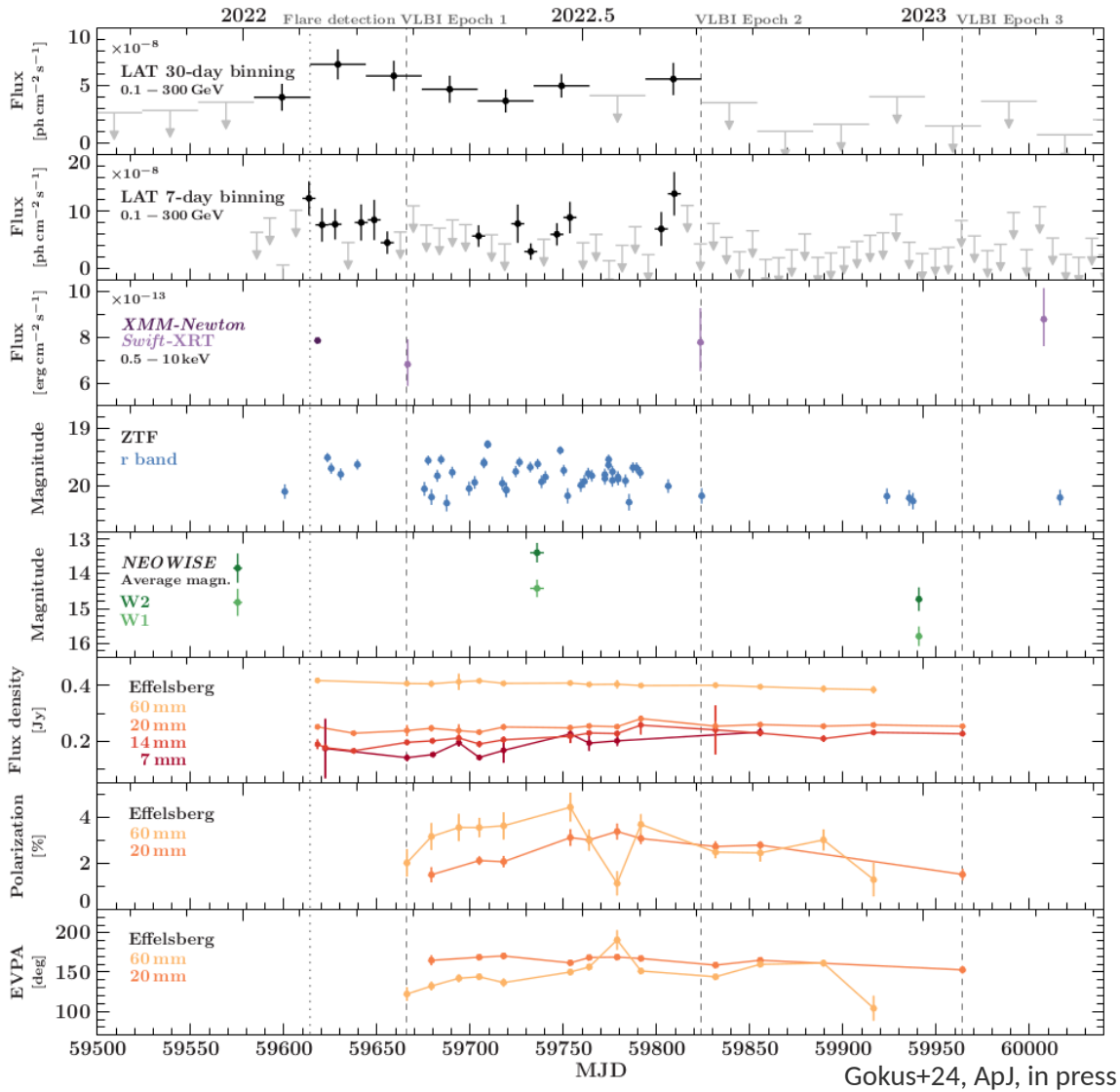

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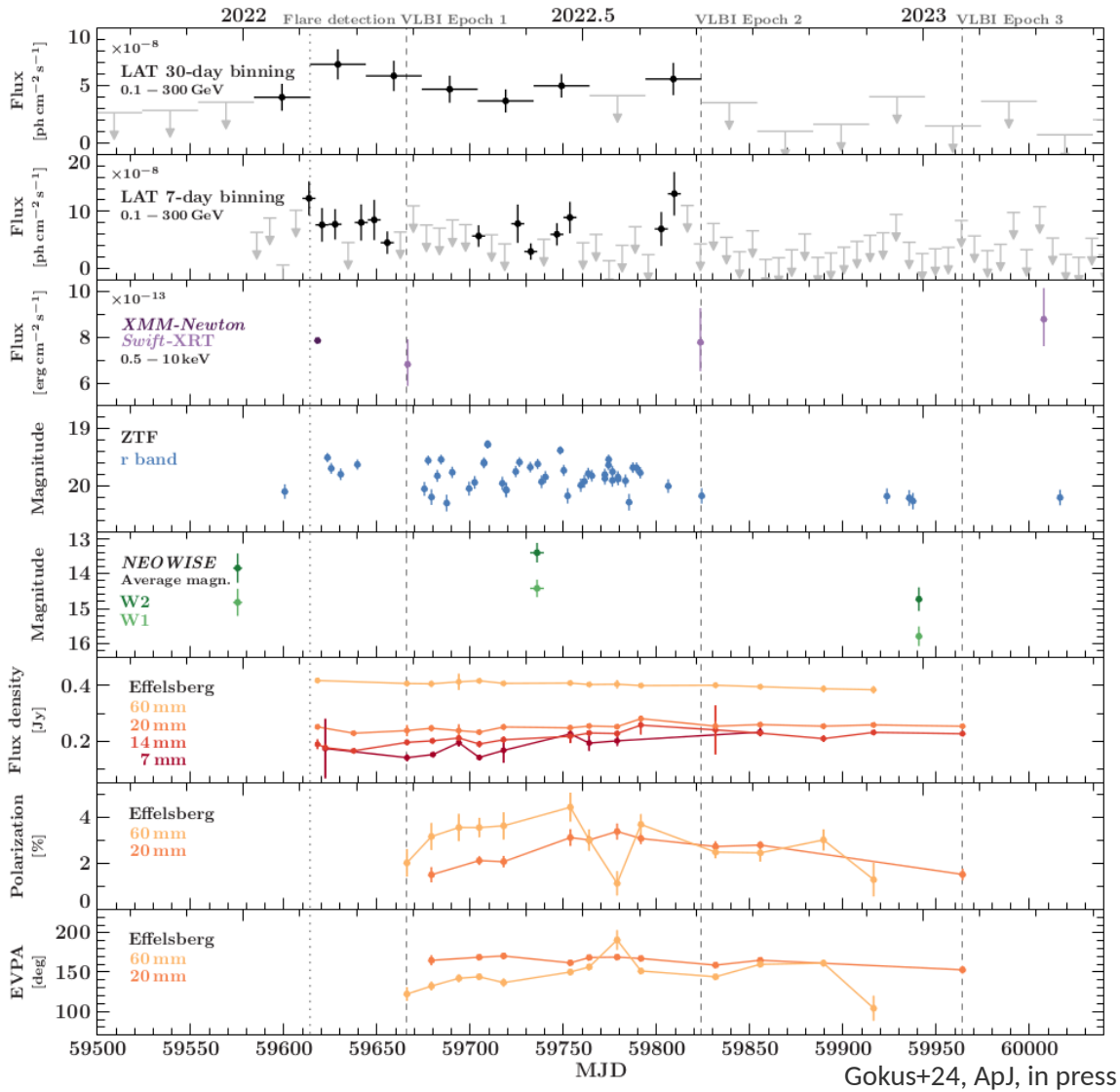

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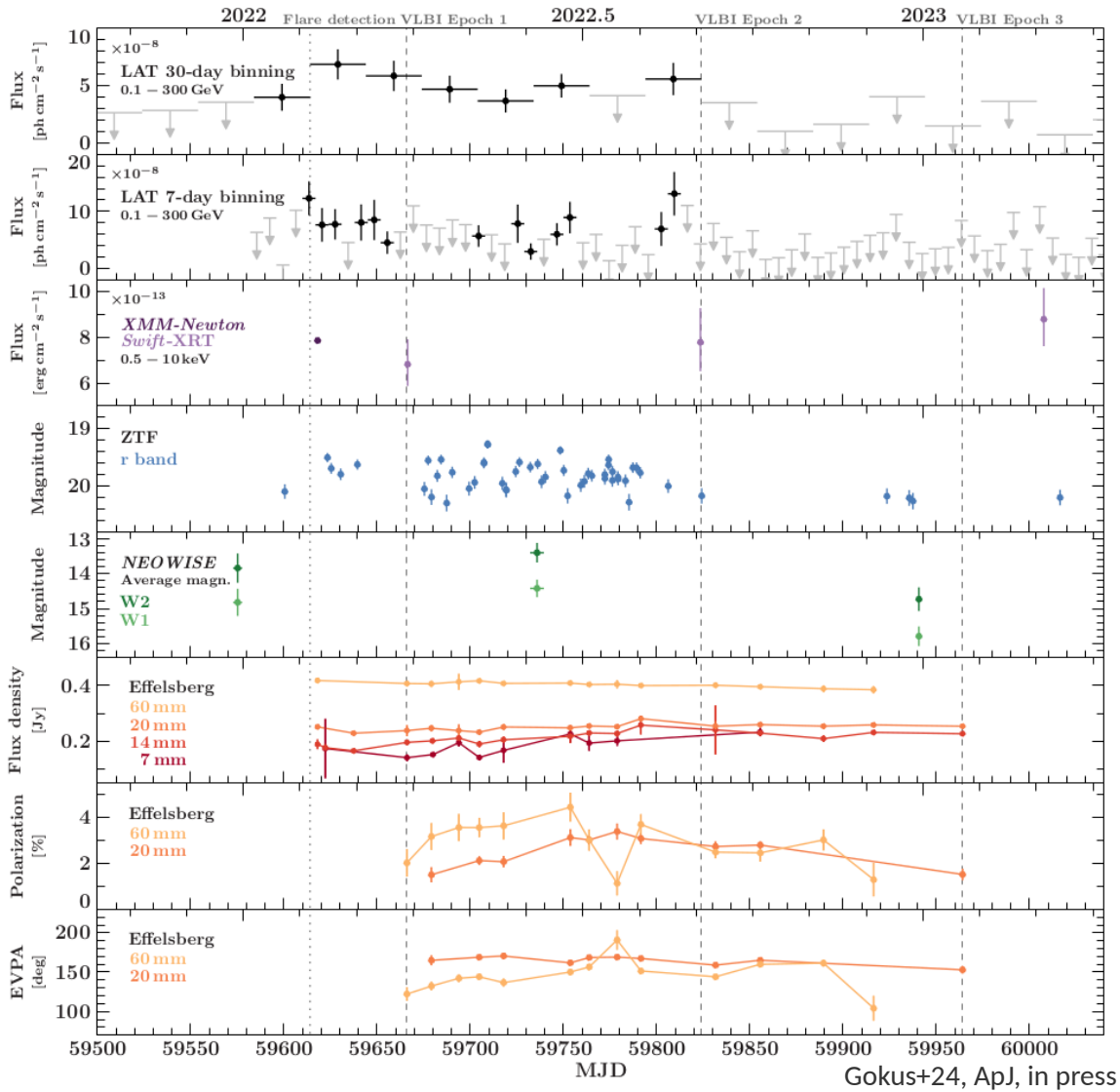

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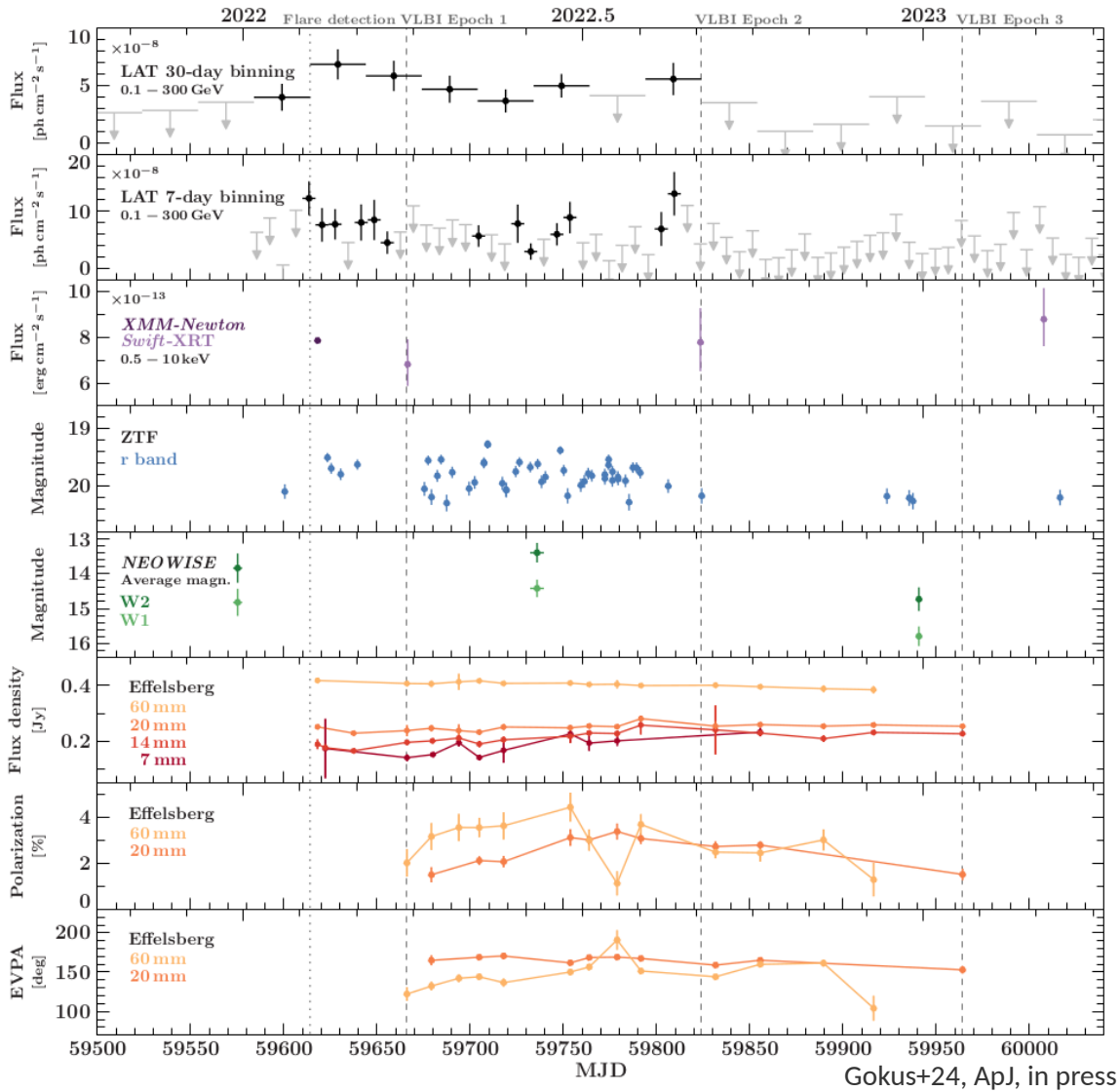
  → during flare: $> 5 \times 10^{49}$ erg/s, only 6 other sources with equally bright or brighter flares
  $> 10^{49}$ erg/s: PKS 0537−286, PKS 0402−362, 3C 454.3, 3C 279
  $> 10^{50}$ erg/s: CTA 102, B3 1343+451



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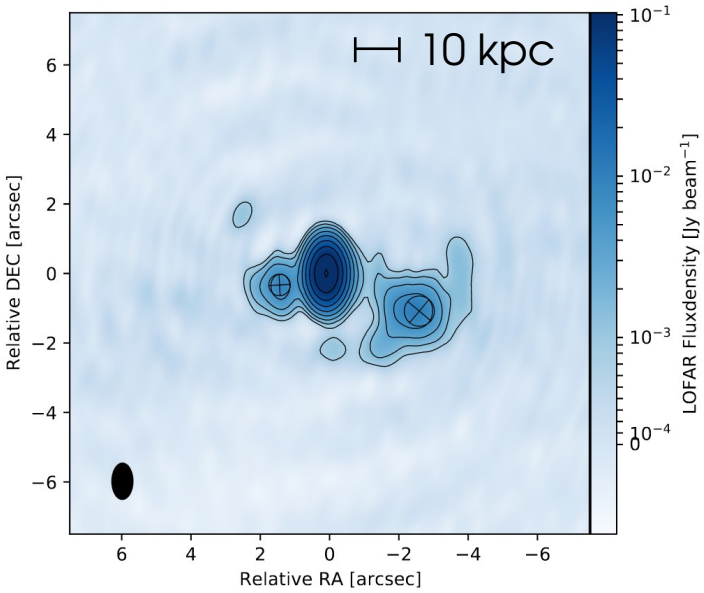
Radio images of TXS 1508+572

144 MHz



LOFAR image
(Kappes et al., 2022, *A&A* 663, A44)

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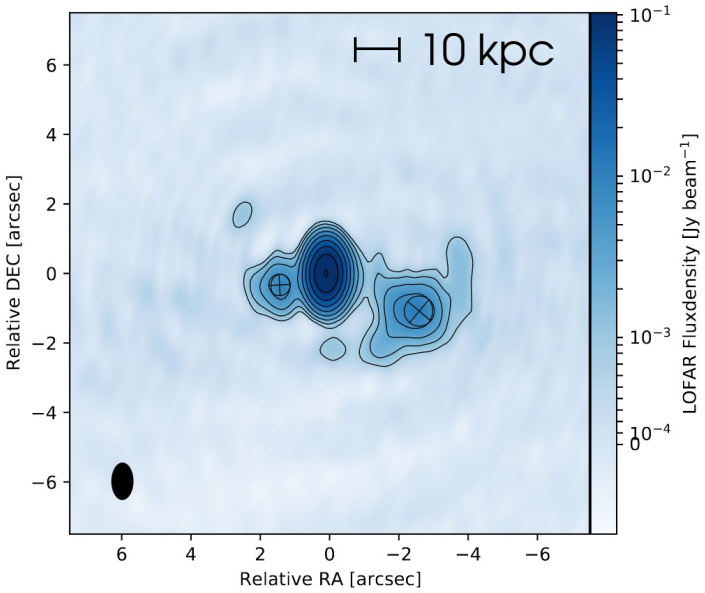

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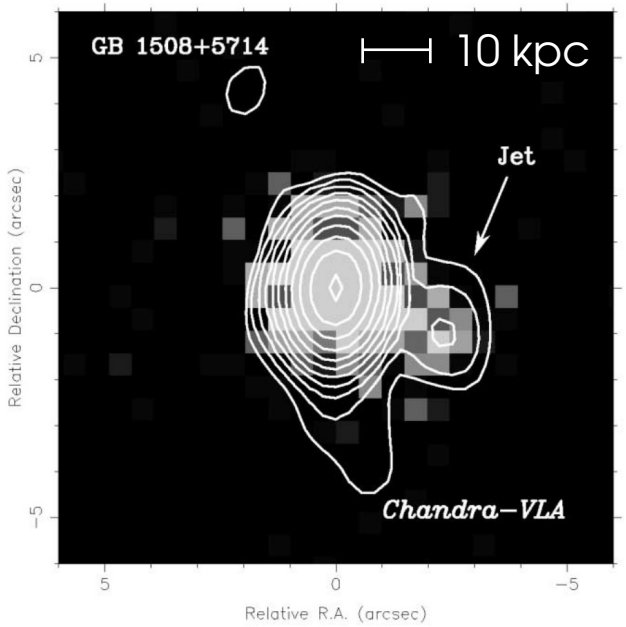
1.4 GHz



VLA contours with
Chandra image
(Cheung, 2004, *ApJ* 600, L23)

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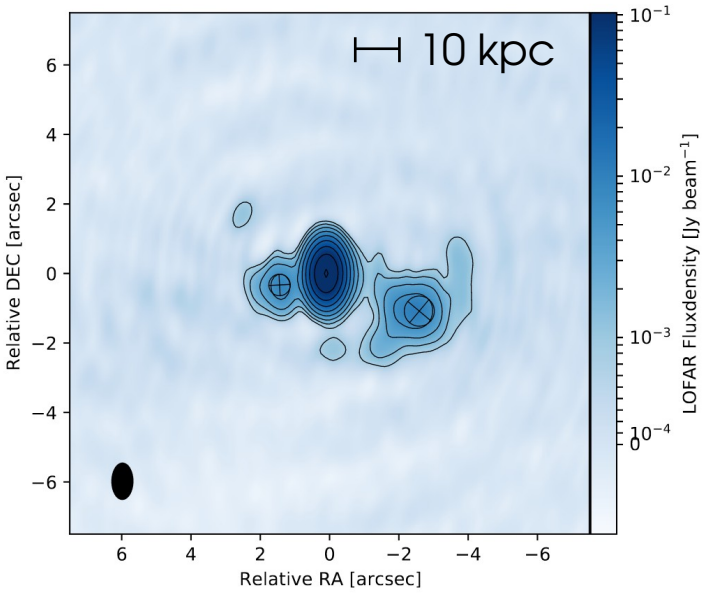

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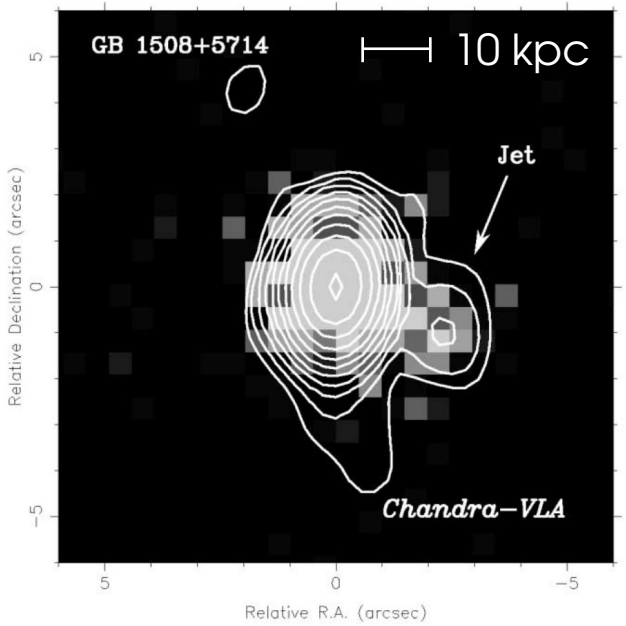

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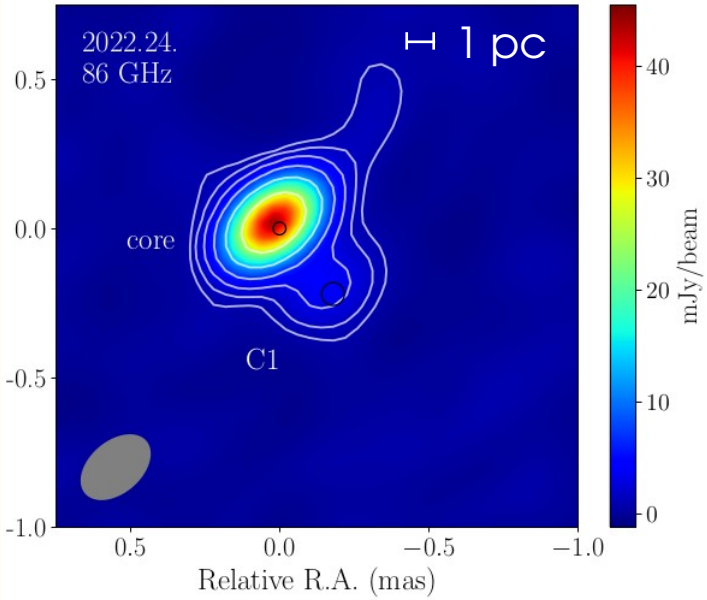

VLBA + Effelsberg + Greenbank
Telescope image
(Benke et al., 2024, *A&A*, 689, A43)

VLBI monitoring of TXS 1508+572

- Due to high redshift, we can observe much higher source intrinsic frequencies:
  15 GHz → 80 GHz (3 epochs)
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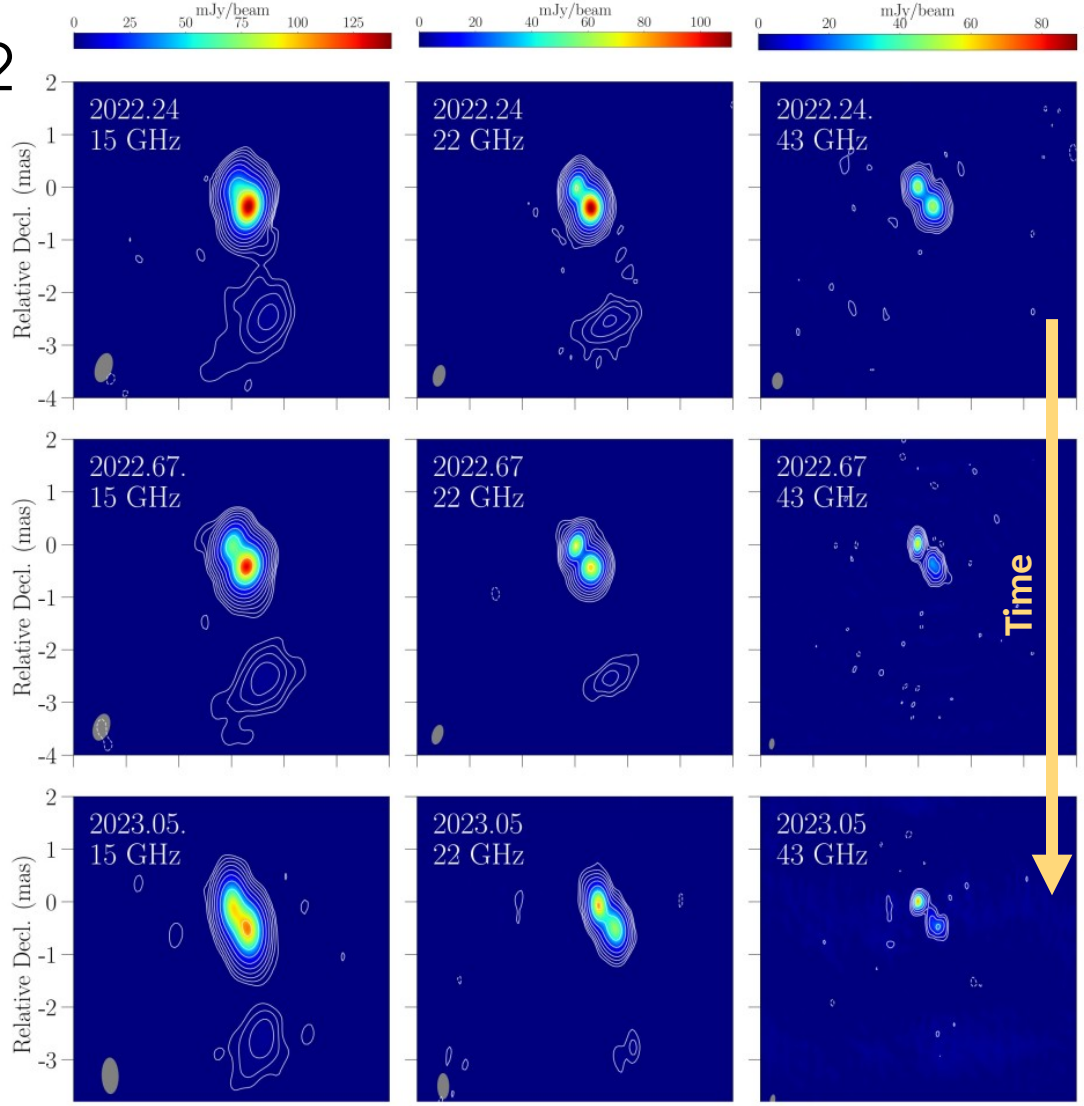

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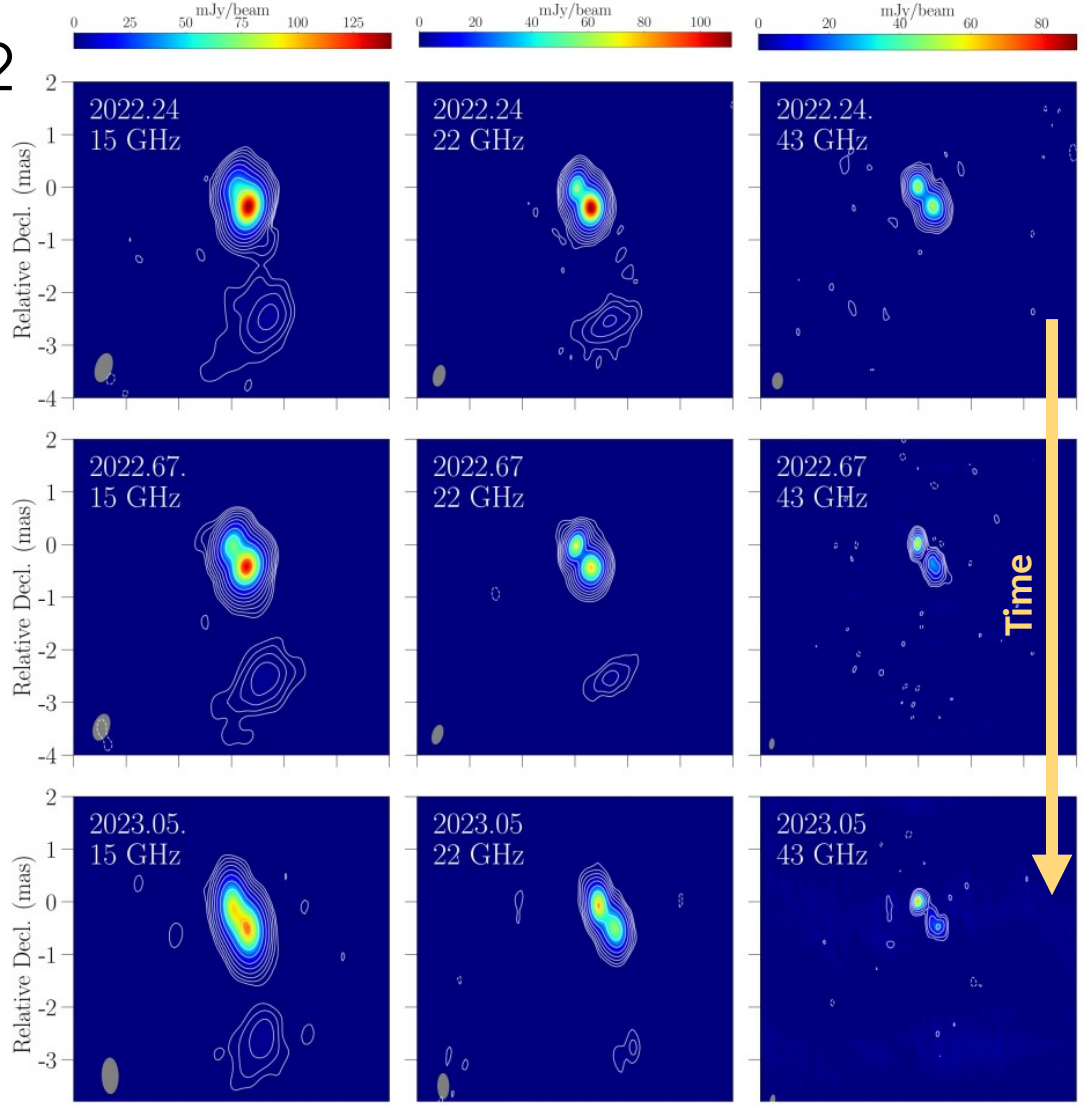

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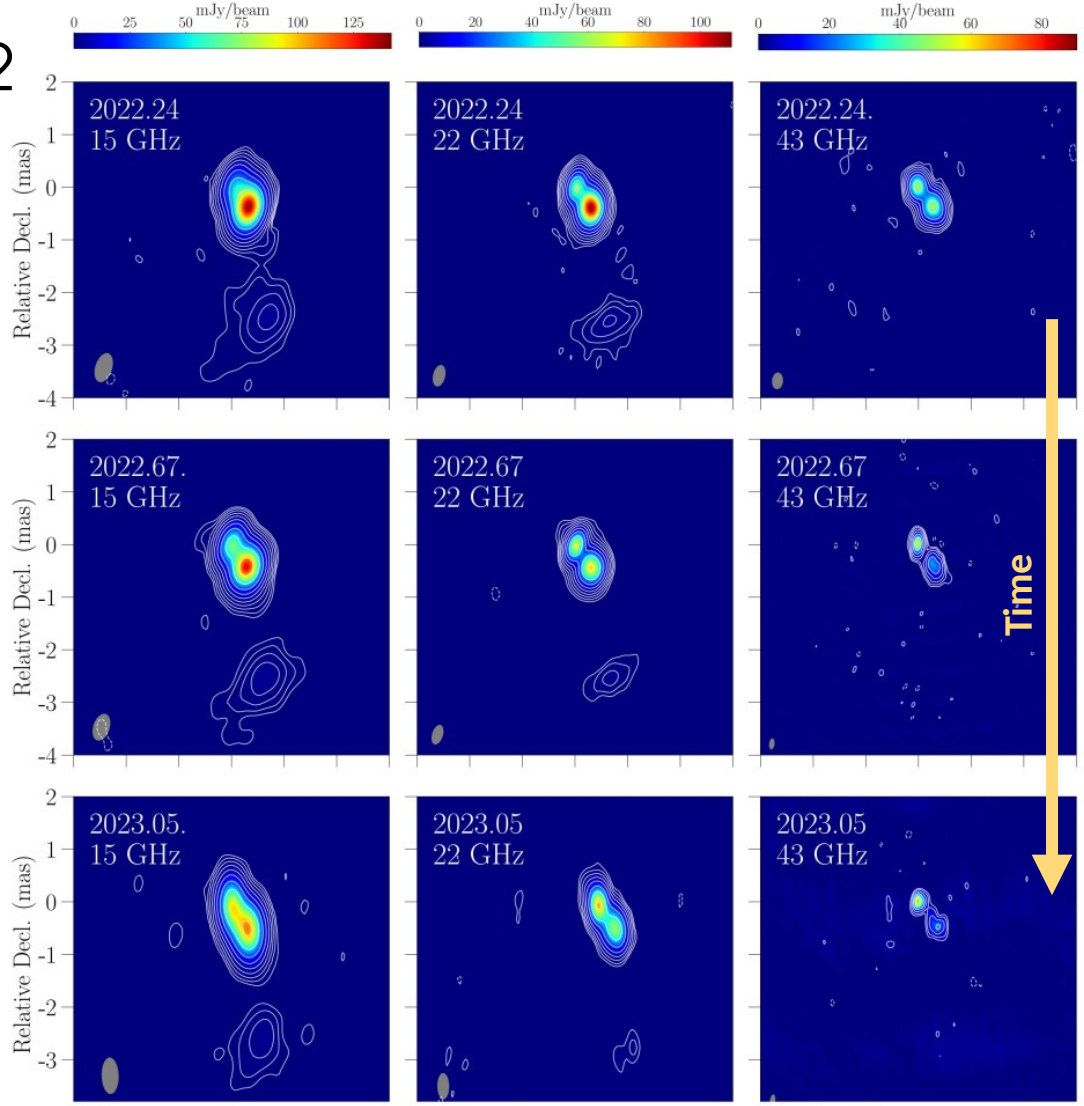
- Kinematic analysis yields apparent jet velocity $\beta_{app} \approx 14.3\ c - 32.2\ c$
  → agreement with bulk Lorentz factor Γ from our SED model
  → originated from core ~ 2016 – 2019
  (not connected to γ-ray flare in 2022)



Benke+24, A&A, 689, A43

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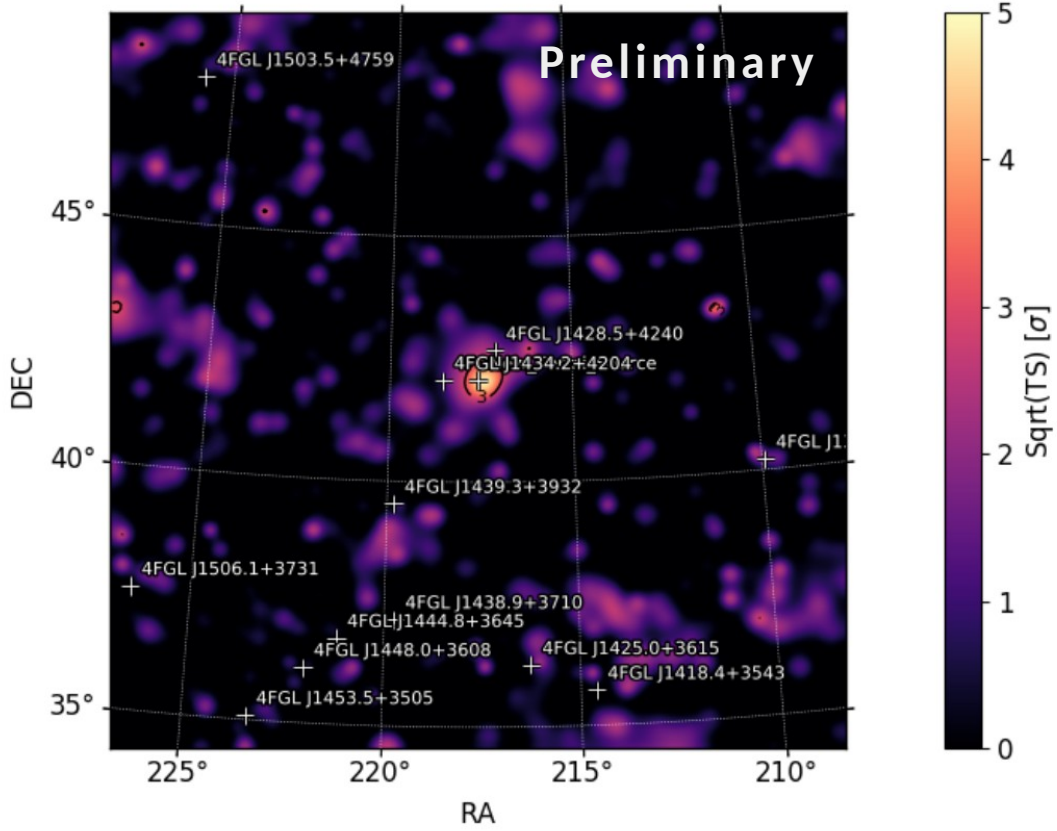
TS map for B3 1428+422, with the emission from the source visible in the center



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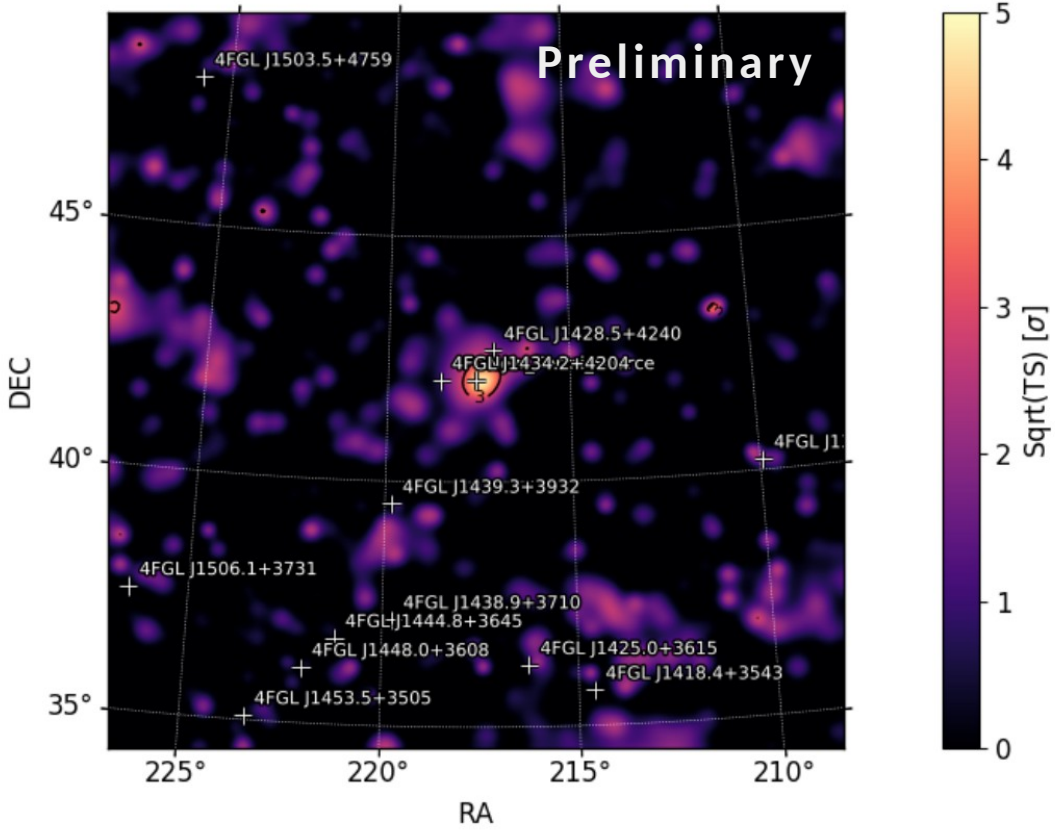

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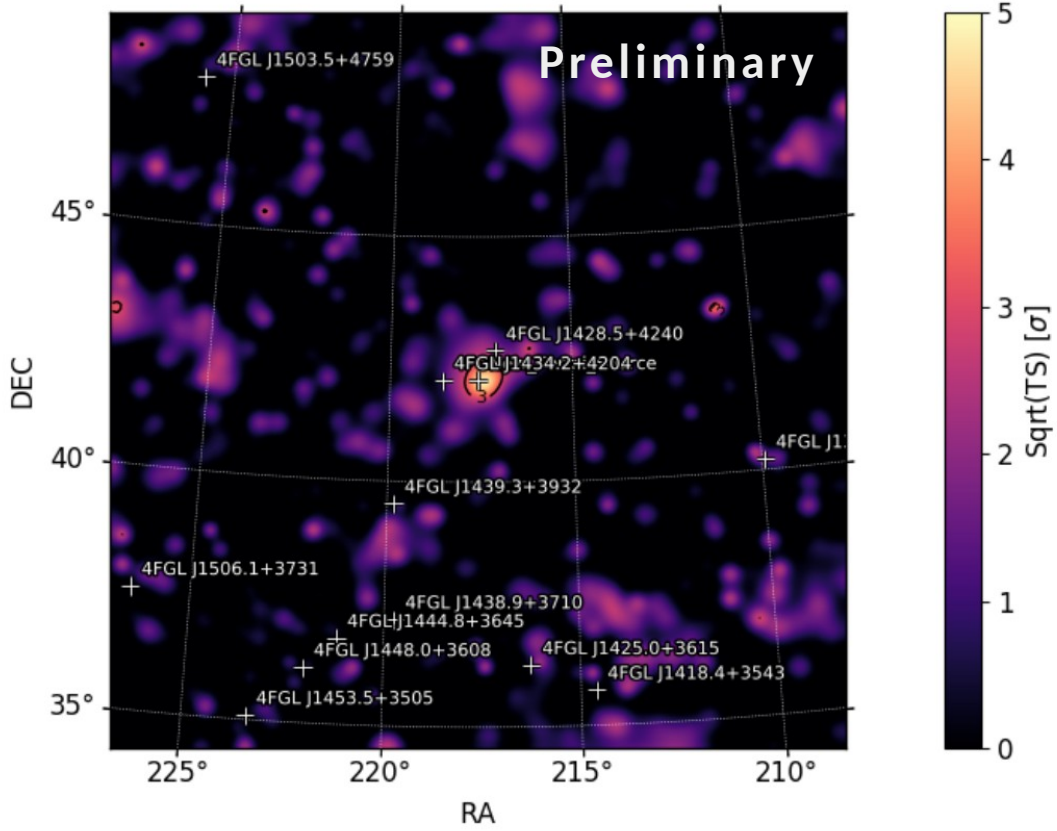

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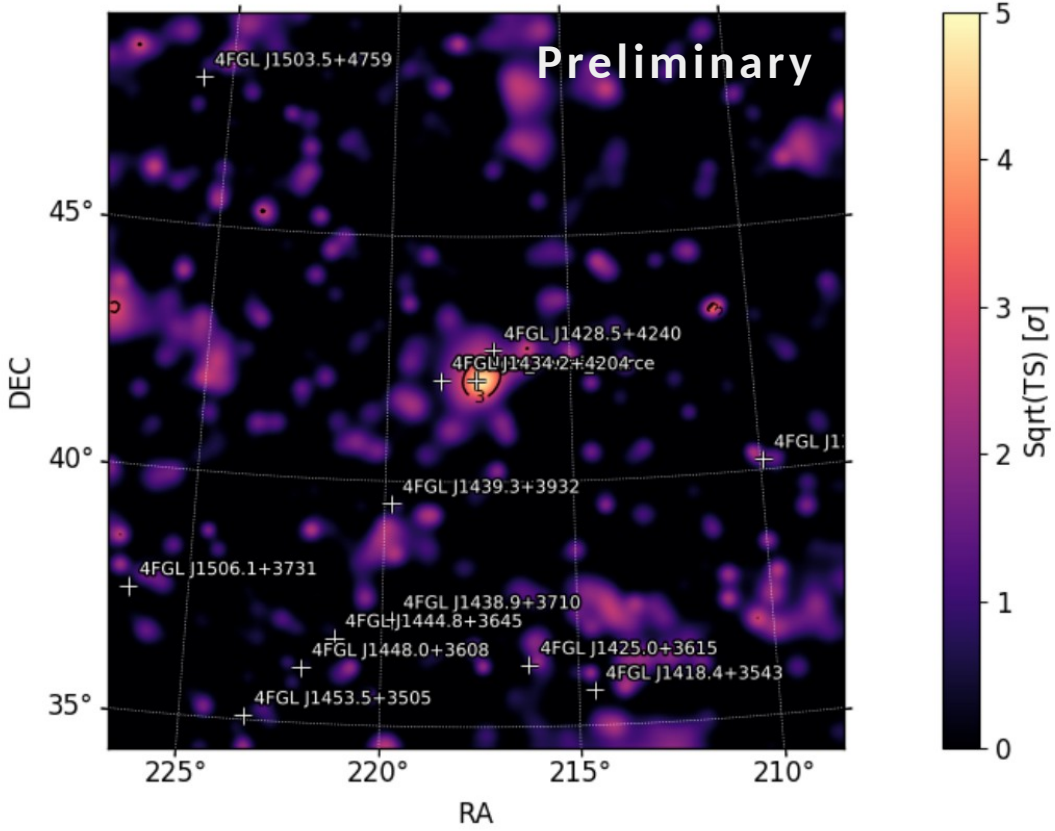

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- Status of high-z blazar projects:
  - Both papers about TXS 1508+572 in press at ApJ / A&A:
    Gokus A. et al., 2024, arXiv:2406.07635 (MWL analysis)
    Benke P., et al., 2024, A&A, 689, A43 (VLBI campaign)
  - B3 1428+422 showed brief flare, coincides with increase in hard X-ray emission

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