Studying multiwavelength properties of γ-ray flaring blazars at redshift > 3

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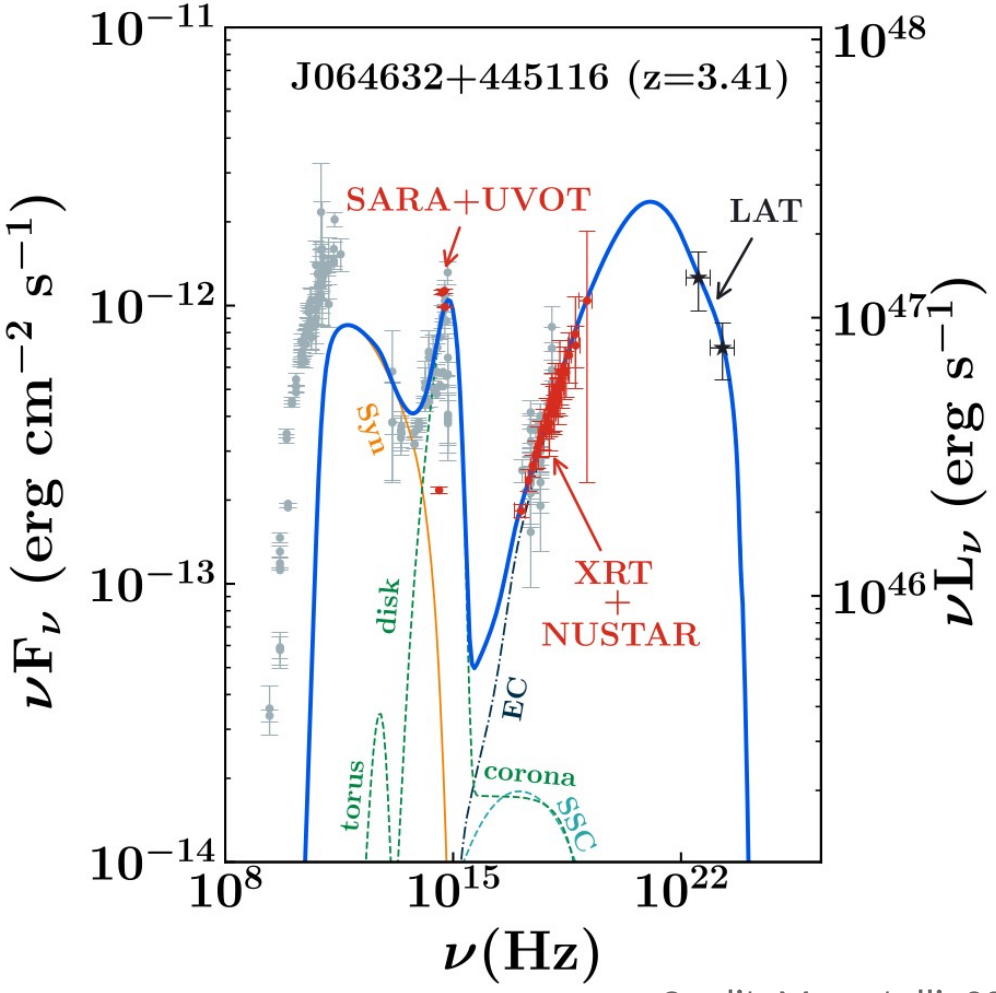
Image Credit: NASA/JPL-Caltech/GSFC

Why interesting?

High-redshift blazars

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

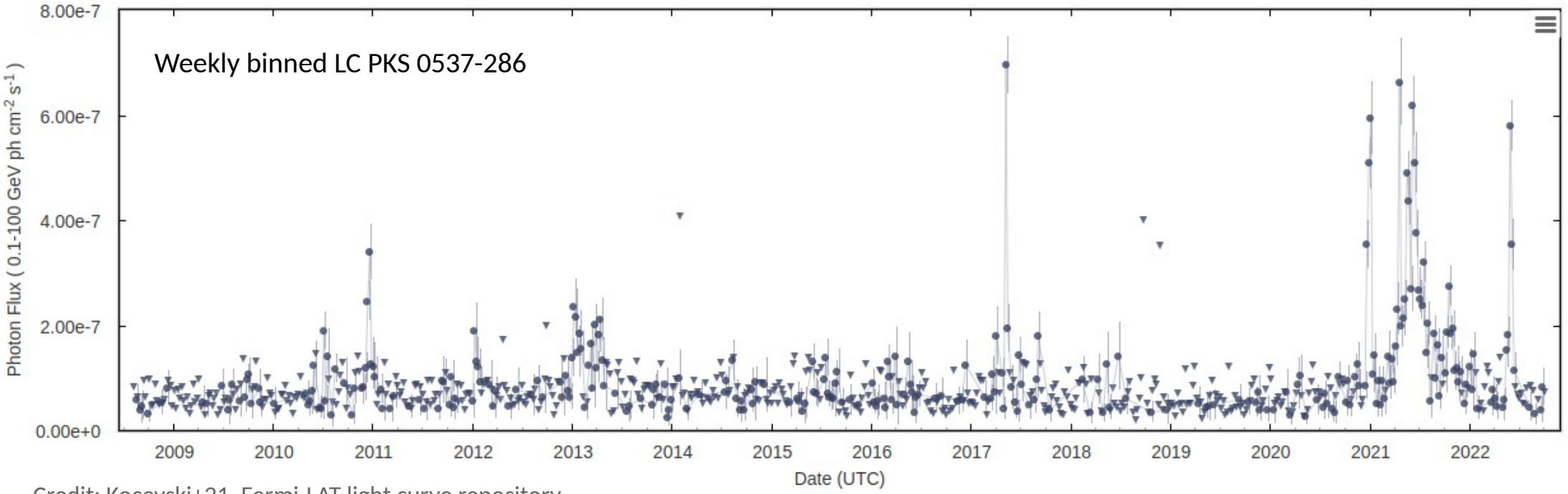
- High-energy hump peaks in MeV band
  → (simultaneous) X-ray and γ-ray data necessary
- Accretion disk emission redshifted to optical/UV range
- One detection implies existence of several hundred similar, misaligned sources [e.g., Sbarrato+14]
- High redshift enables radio observations of regions closer to SMBH



Credit: Marcotulli+20

Search for γ-rays from high-z sources

- Accumulating *Fermi*-LAT data & report in catalogs
- Monitoring of daily sky (LAT Flare Advocates) → PKS 0537-286 (z = 3.1)
- Search for signal on monthly time scales: Kreter+20
  → Using approach to gather simultaneous MWL data set with pipeline
  → Monitoring 80 sources reported in BZCAT with $z > 3$ & daily check



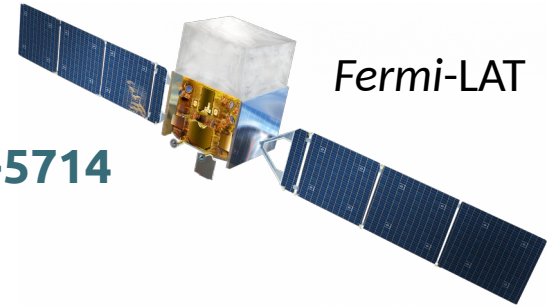
Credit: Kocevski+21, Fermi-LAT light curve repository

TXS 1508+572

a.k.a. 4FGL J1510.1+5702, GB 1508+5714

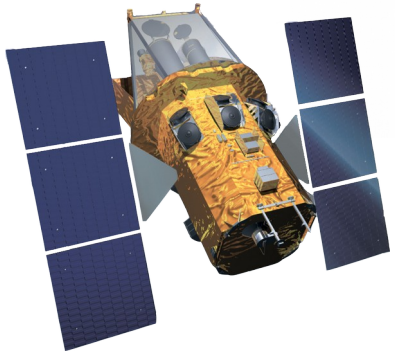
- Redshift z = 4.3 [Hook+95]
- Flare detected on Feb 4 2022 → 25 x 4FGL flux in 5-day interval [Atel #15202, Gokus+22]
- γ-ray luminosity: (3.5 +/- 1.4) x 10^{49} erg/s
- Observational multi-wavelength campaign

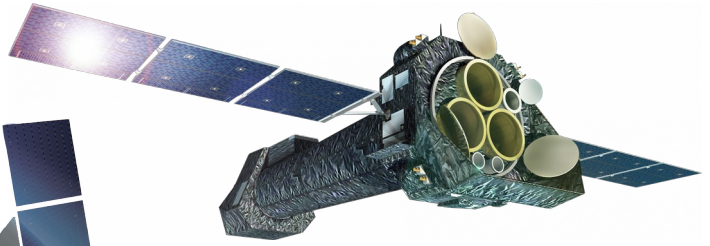
Credit: NASA Spacecraft Icons



Fermi-LAT

Swift





XMM-Newton

Steward Observatory

Credit: A. I. Marineau

Hobby Eberly telescope

Credit: M. Harris/McDonald Observatory/UT-Austin

100-m Effelsberg radio telescope

Credit: Florian Eppel

VLBA

Credit: NRAO

TXS 1508+572

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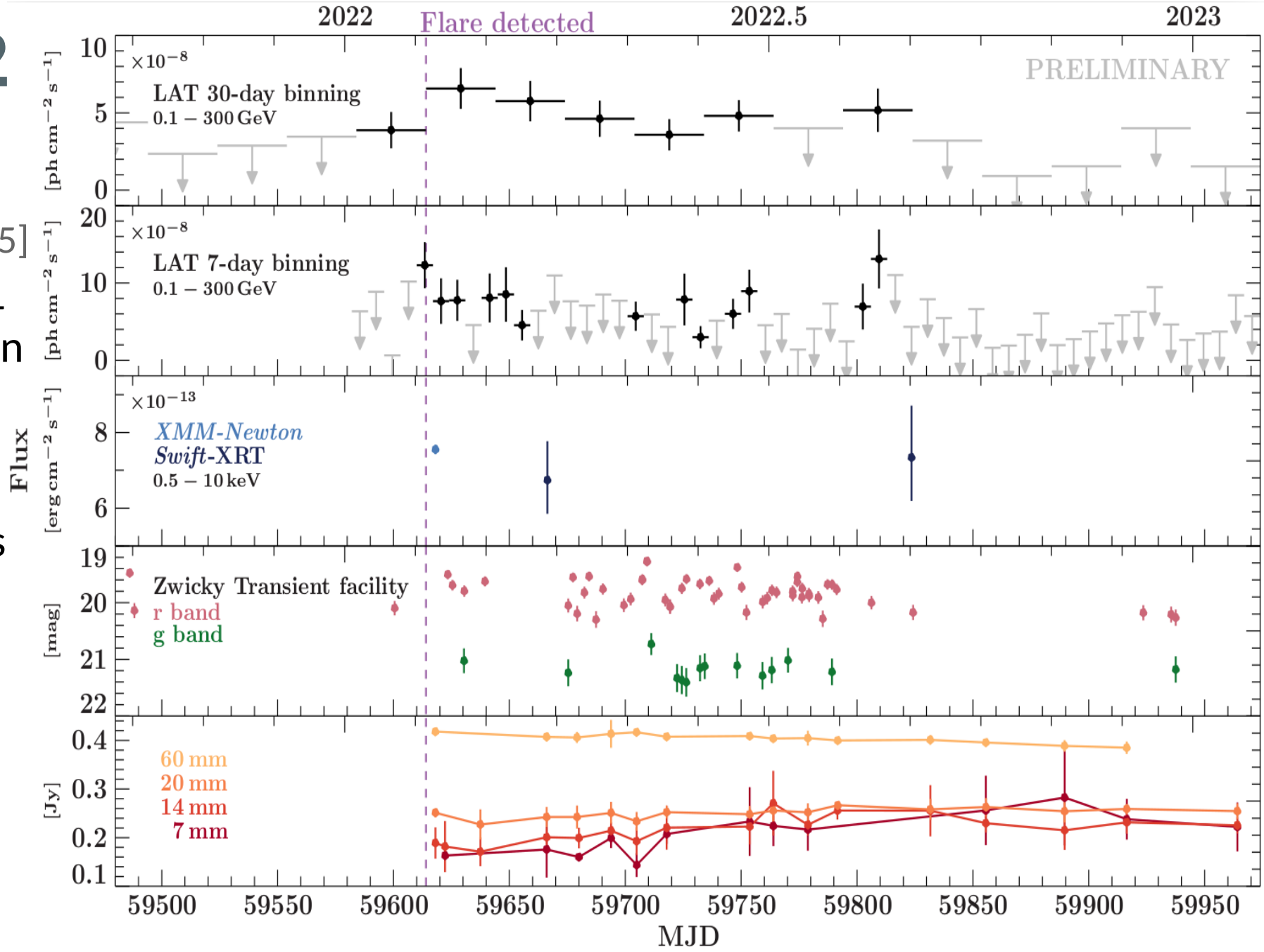
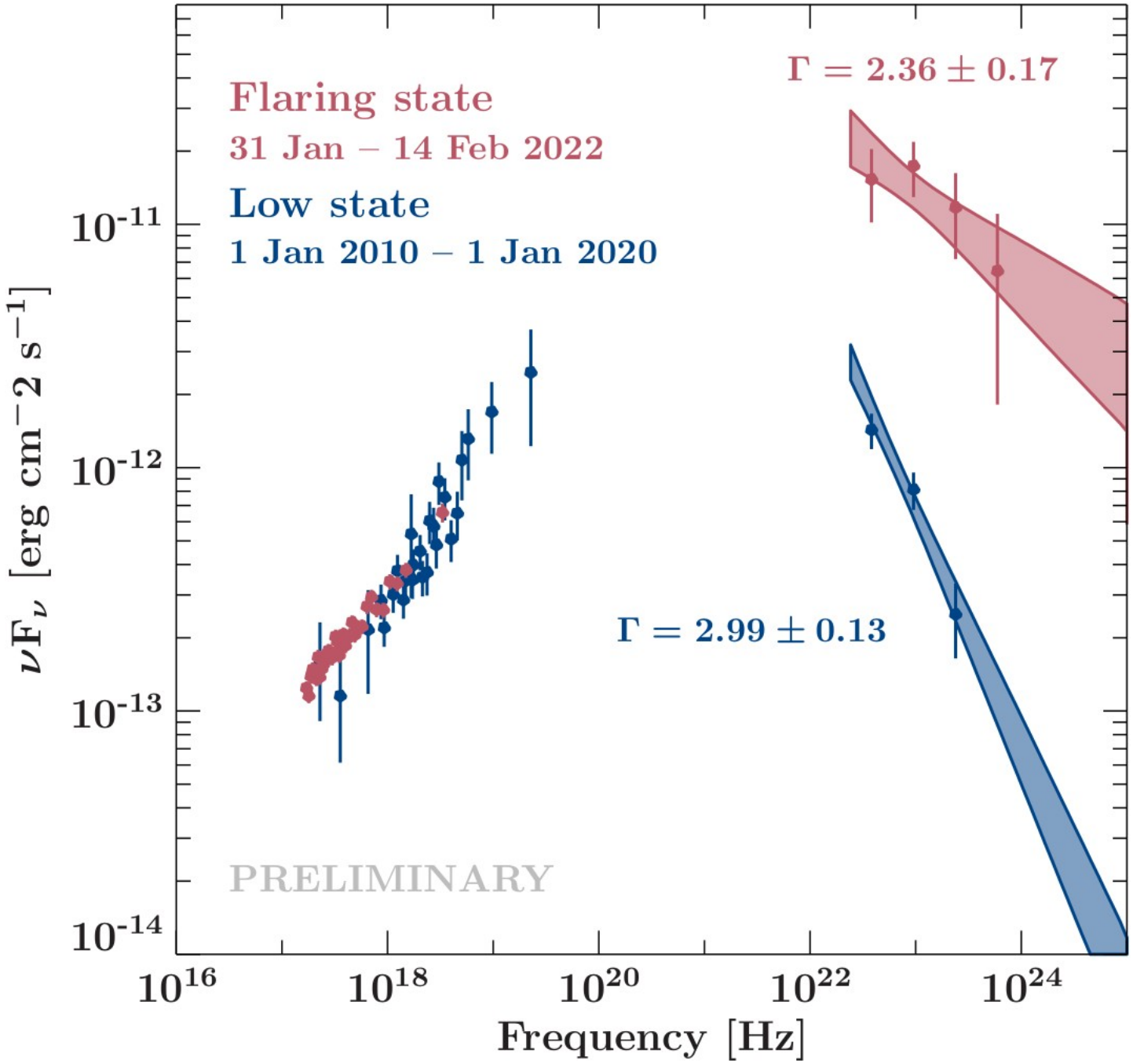


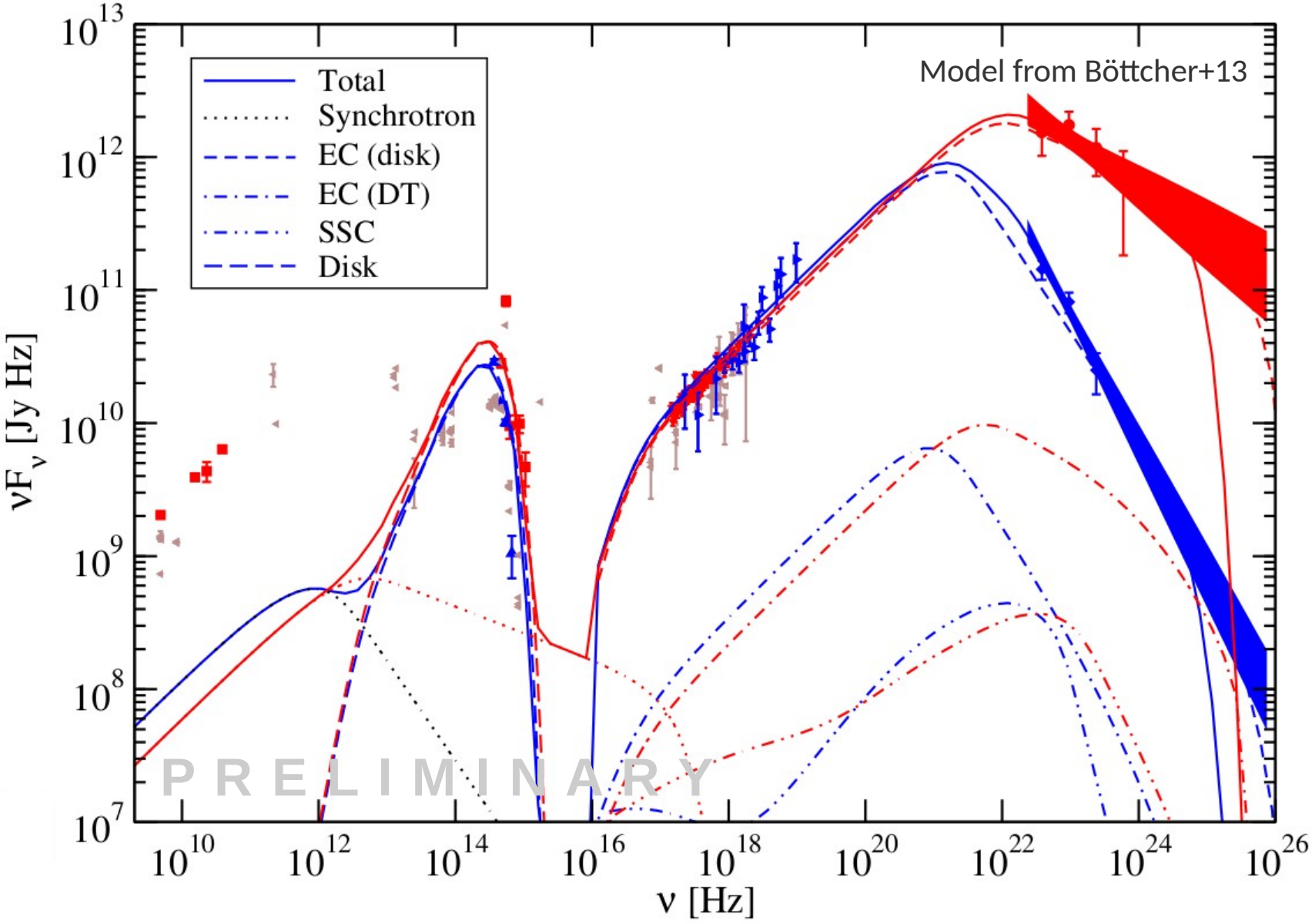
High-energy SED

- During flare:
  - Flux change only visible in γ-rays
  - γ-ray spectrum significantly harder
- Quiet state: NuSTAR observation available → Γ consistent with flaring state
- Broadband SED modelling → determine CD & dominant processes



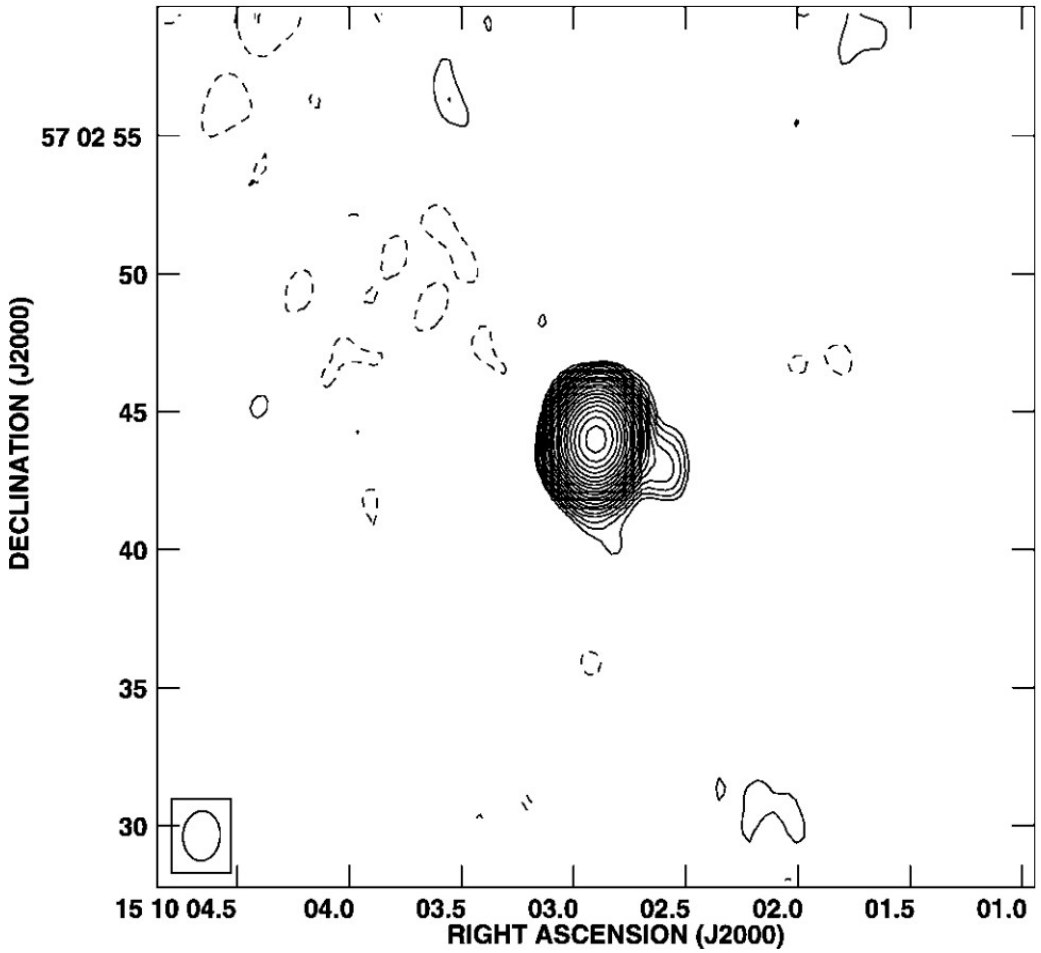
Broadband SED modelling

- Leptonic emission, γ-rays mainly from EC from disk
- Very large black hole mass ($2 \cdot 10^{10}$ $M_\odot$) necessary to explain optical emission
- Change in electron acceleration to explain harder electron spectrum?
- Optical spectropolarimetry observation just done → better constraint on disk contribution



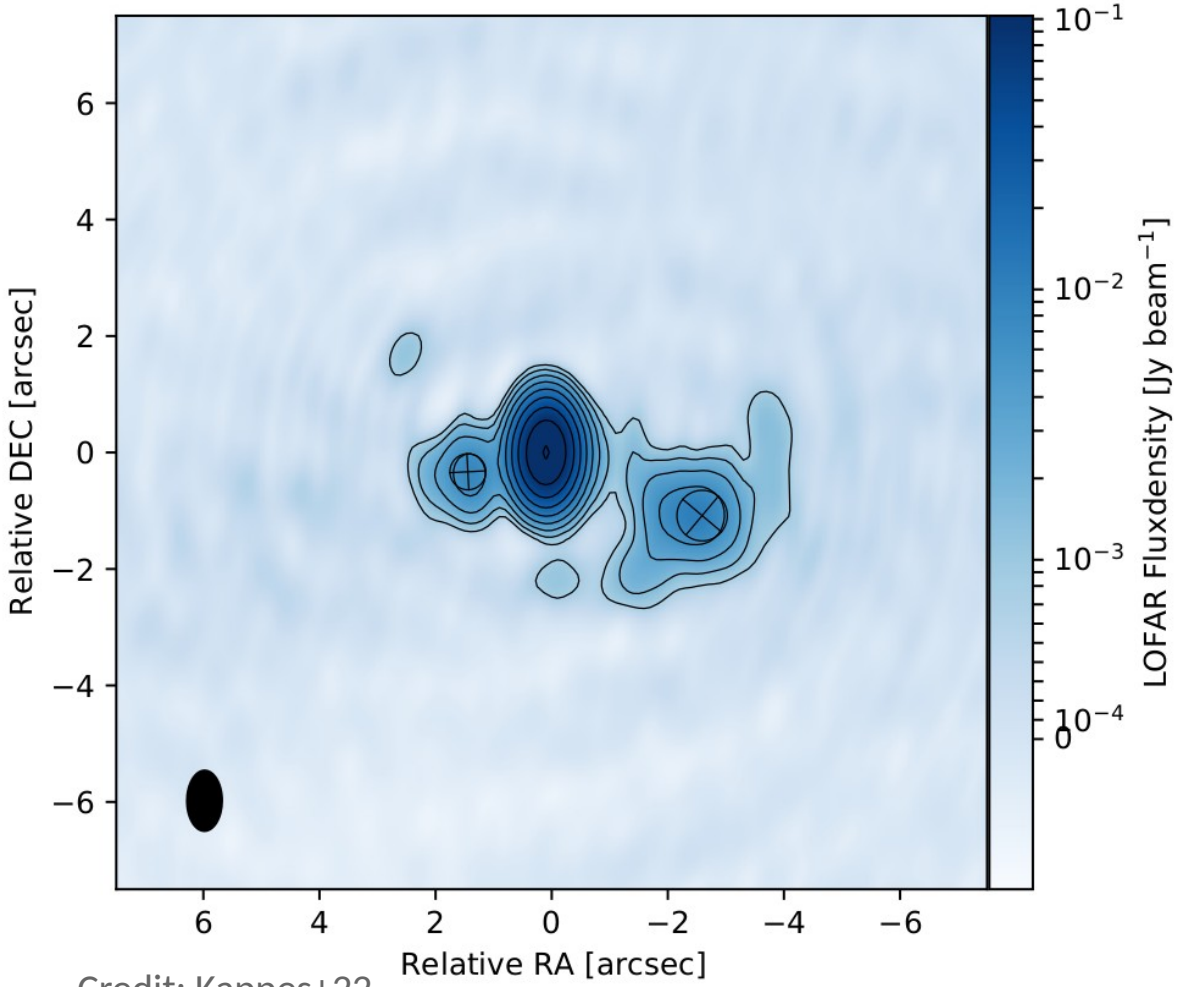
Radio VLBI observations - Archival

1.4 GHz VLBA image



Credit: Cheung 04

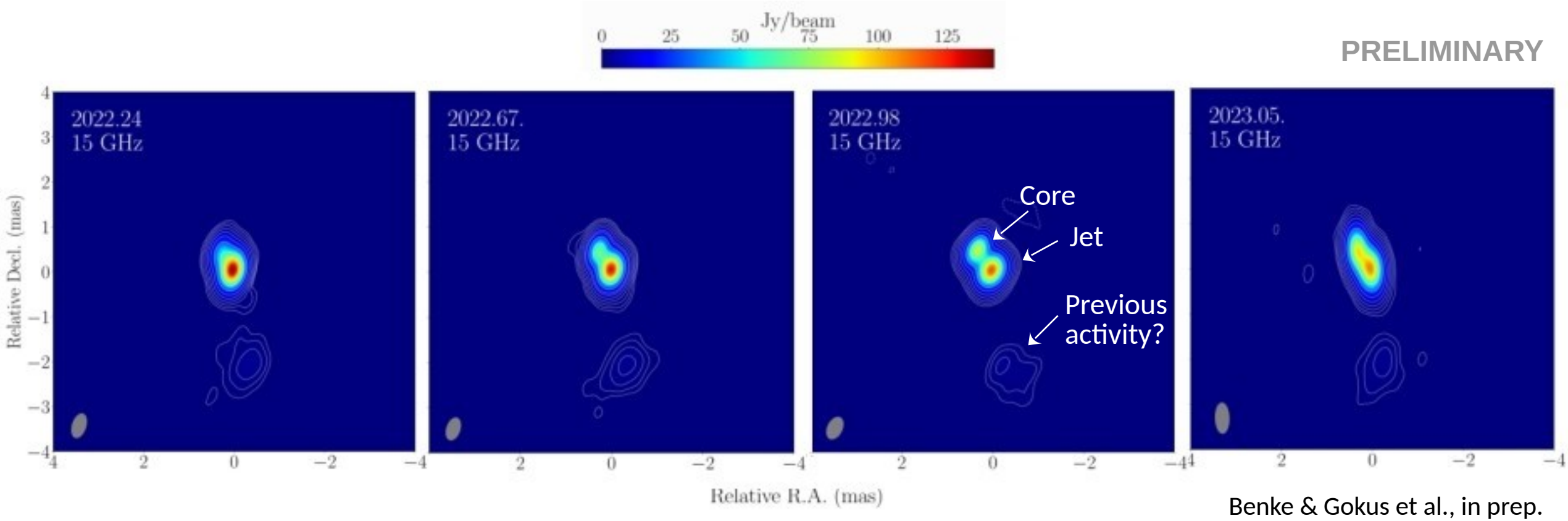
144 MHz LOFAR image



Credit: Kappes+22

Radio VLBI observations – Our campaign

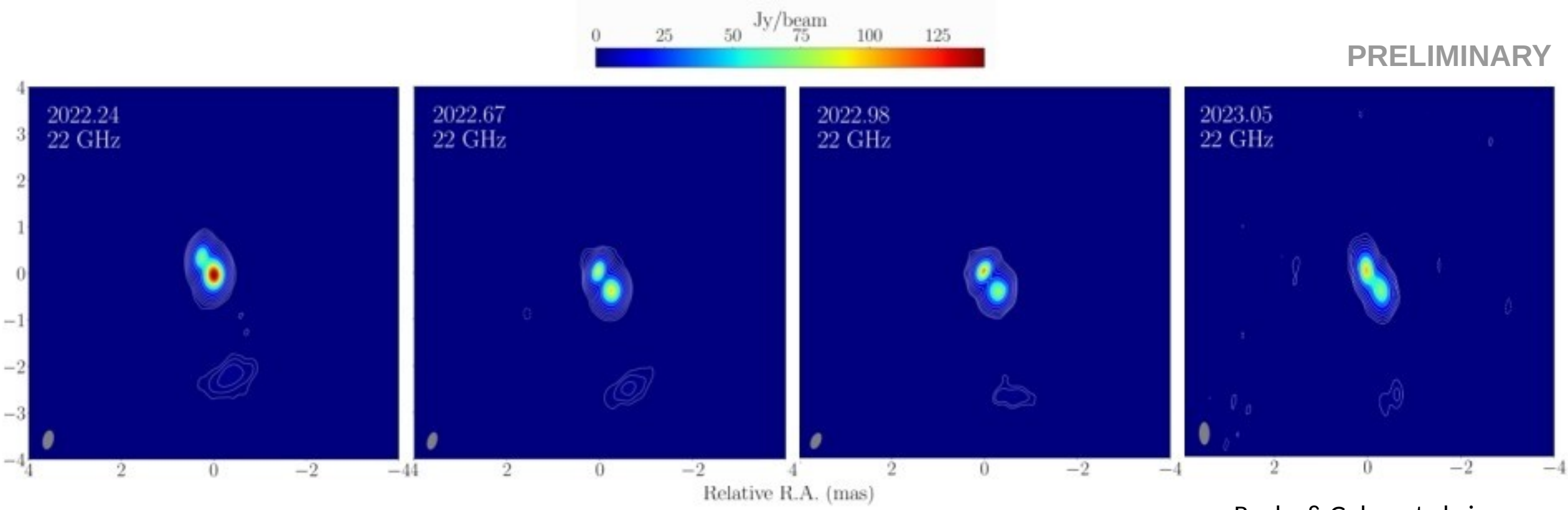
VLBA + Effelsberg - 15 GHz | 79 GHz



Benke & Gokus et al., in prep.

Radio VLBI observations – Our campaign

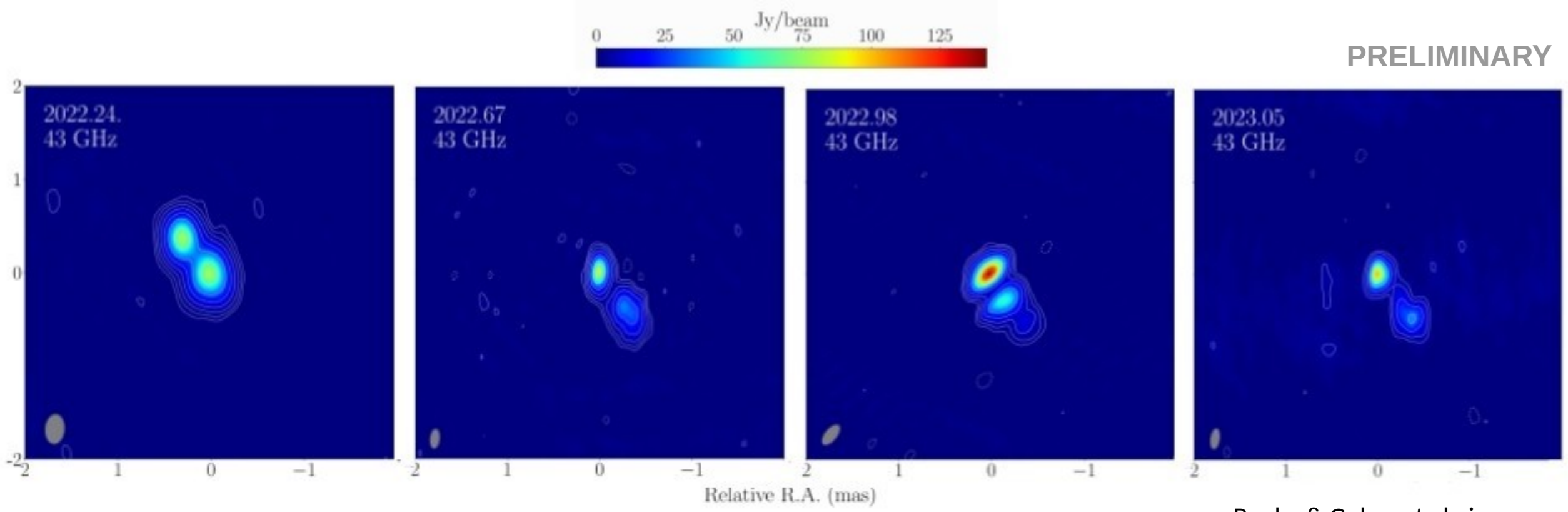
VLBA + Effelsberg - 22 GHz | 117 GHz



Benke & Gokus et al., in prep.

Radio VLBI observations – Our campaign

VLBA + Effelsberg - 43 GHz | 228 GHz

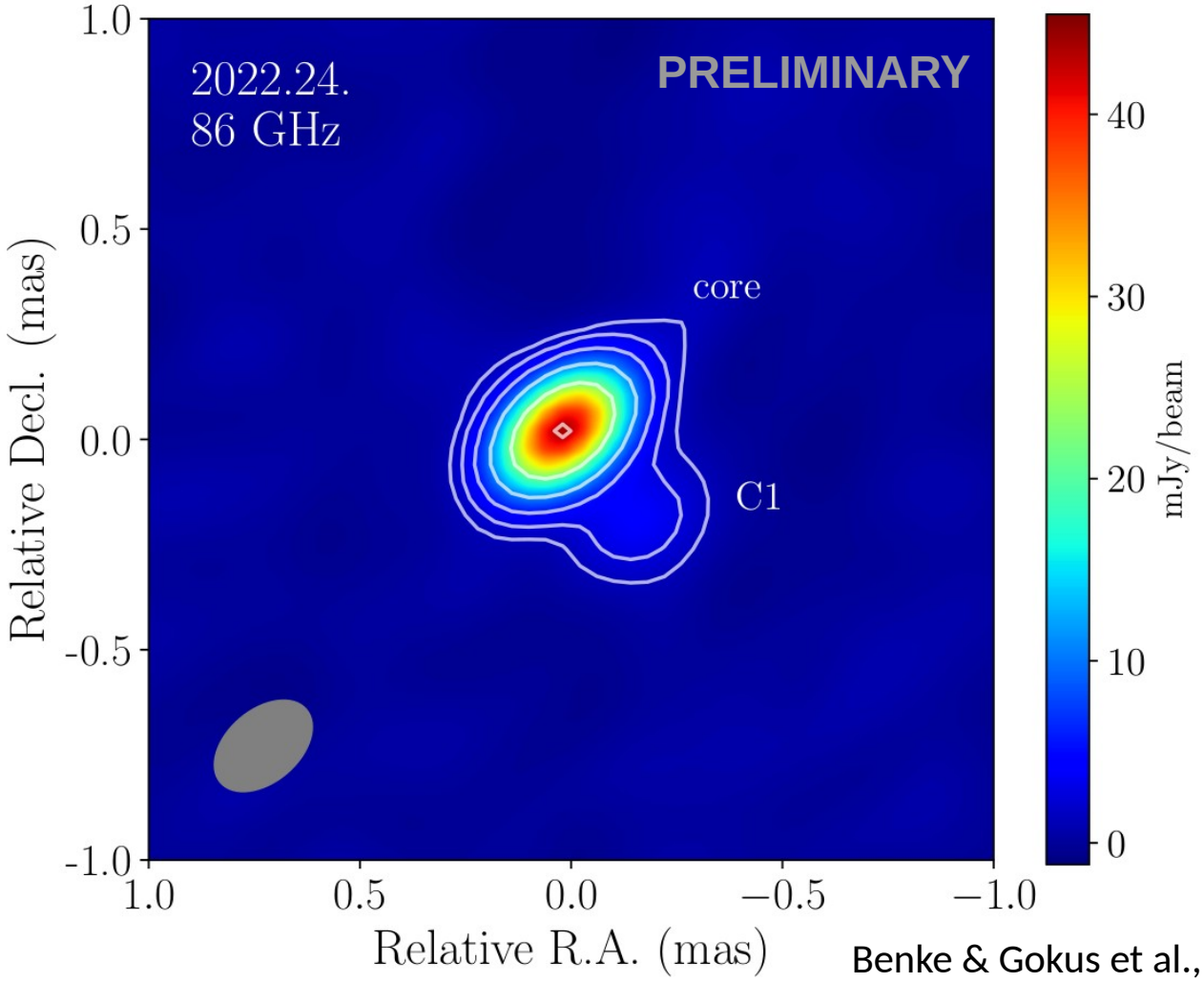


Benke & Gokus et al., in prep.

Radio VLBI observations – Our campaign

VLBA + Effelsberg - 86 GHz | 456 GHz

- Probing higher intrinsic frequencies than EHT observations!
- Very compact morphology
- Tentative signal from jet component



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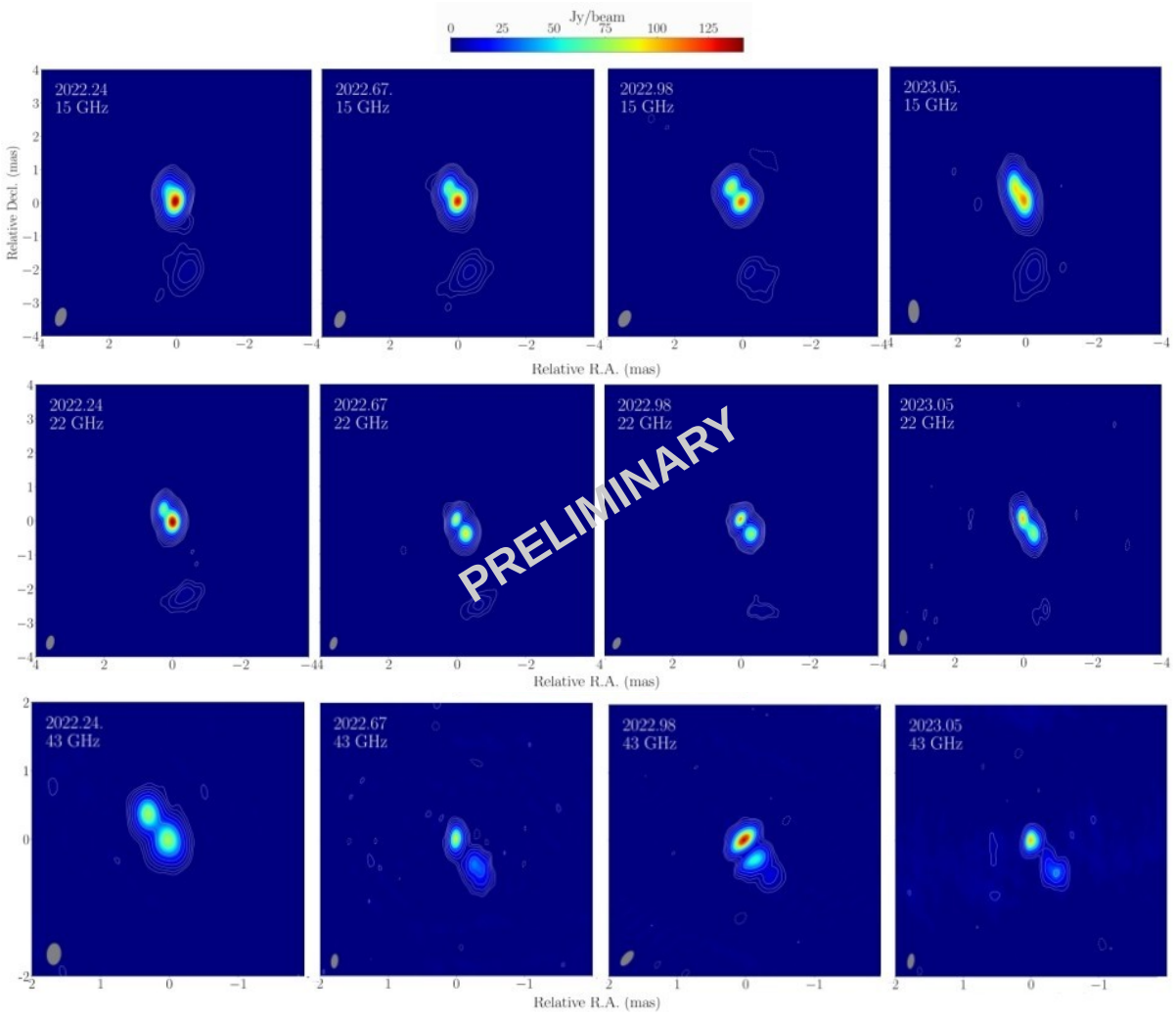
Radio VLBI observations – Our campaign

- Morphological changes visible on monthly timescales
- Measured speed in campaign agrees with VLBI monitoring of jet component over several years → v = 0.1 mas/yr [Gurvits+23]
- Superluminal speed: v_{app} ~ 20 c



Conclusions

- Existing pipeline to search for high-redshift blazar flares
  → expect 1-2 events per year
- 1st quasi-simultaneous observations of flaring blazar at $z > 4$
- γ-ray luminosity ~ 3 x 10^{49} erg s^{-1} → possibly 2nd most luminous blazar flare
- VLBI campaign → probing frequencies up to ~450 GHz
- Multiwavelength analysis in progress
- Pathfinder project for future MeV missions

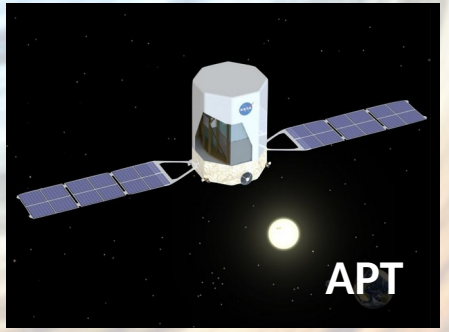


Image Credit: NASA/JPL-Caltech/GSFC