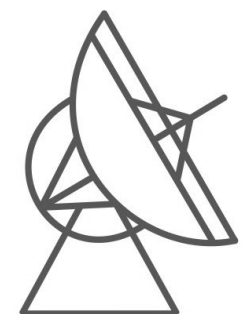


F-GAMMA / QUIVER

Full-Stokes, multi-frequency radio monitoring of *Fermi* blazars

Ioannis Myserlis - Instituto de Radioastronomía Milimétrica (IRAM), Granada, Spain

Emmanouil Angelakis - (Visiting Scientist) National and Kapodistrian University of Athens, Greece

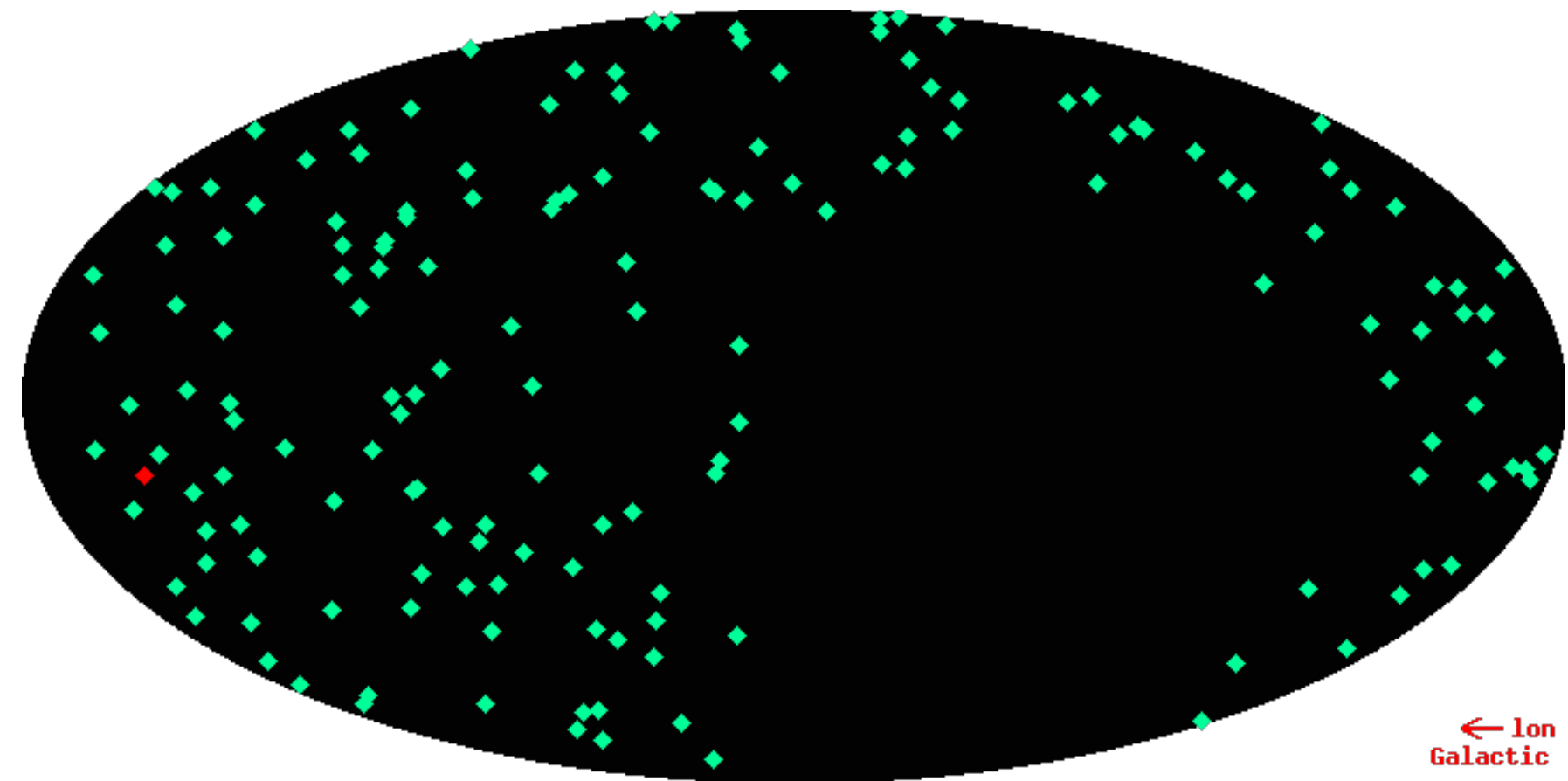


Extragalactic jets on all scales - launching, propagation, termination

17.06.2021

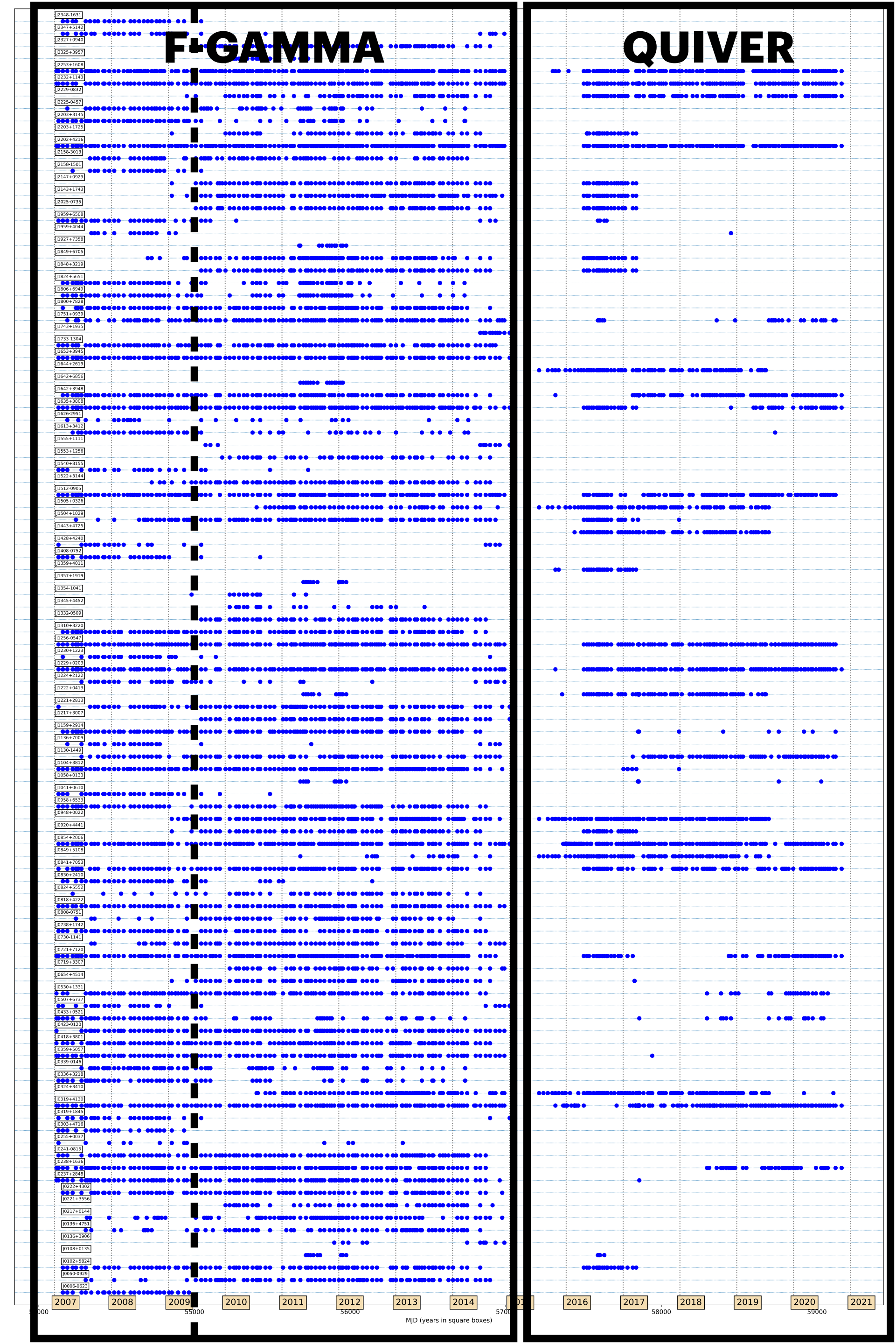
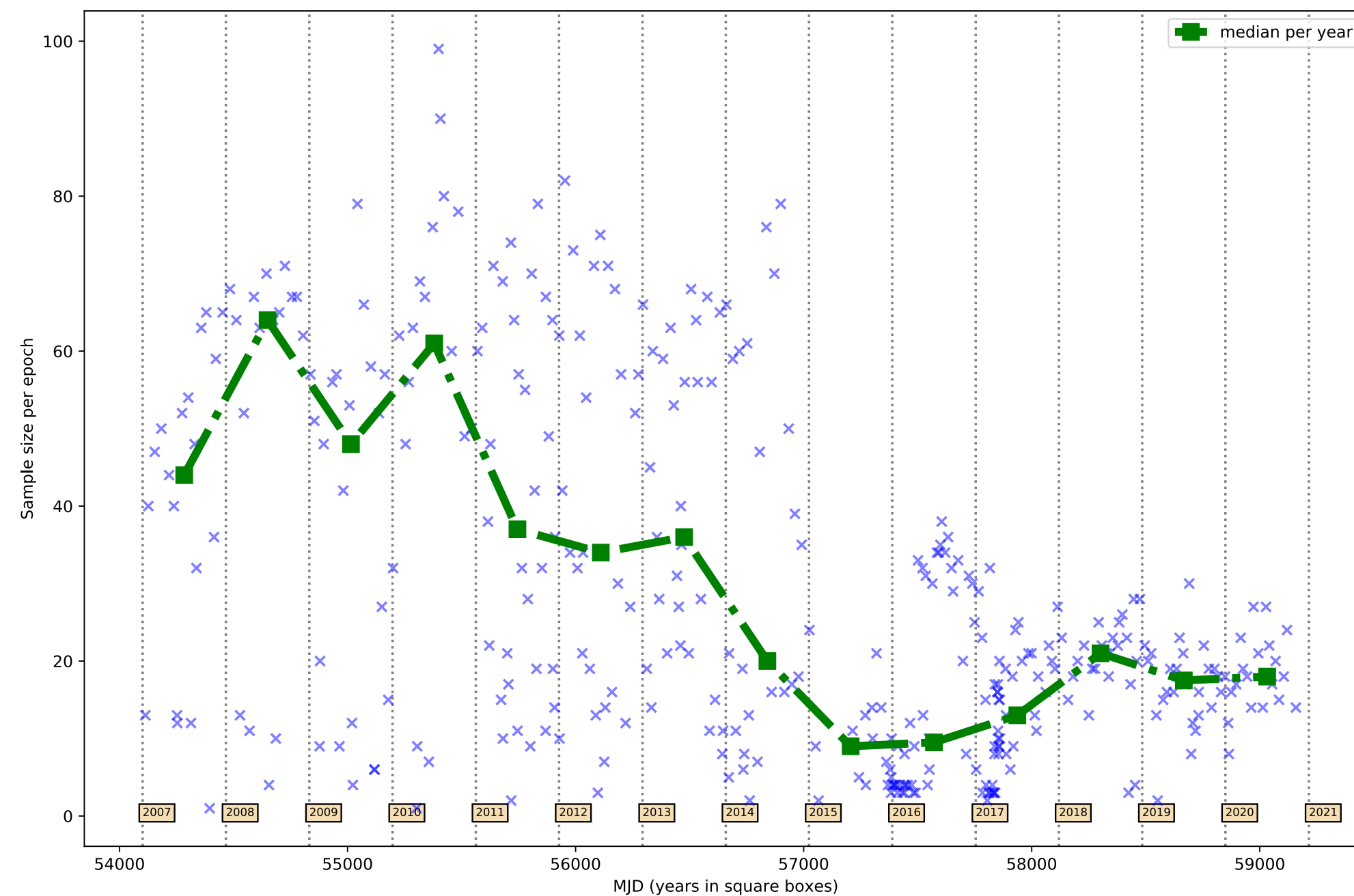
The scope

- F-GAMMA | 2007 - 2015
 - complement the operation of *Fermi* gamma ray telescope
 - monitoring the variable multi-frequency radio emission of AGN jets
- QUIVER | 2015 - now
 - focuses on a sub-sample of highly polarized sources, monitored with higher cadence
- The sample
 - ~300 sources observed at least once
 - ~100 sources monitored regularly
 - uniform northern sky coverage (min. declination $\sim -23^{\circ}24'$)
- More information & 1st data release (2.6 - 43 GHz, 2007-2015)
 - [Fuhrmann, Angelakis, Zensus et al. 2016, A&A, 596A, 45F](#)
 - [Angelakis, Fuhrmann, Myserlis et al. 2019, A&A, 626A, 60A](#)



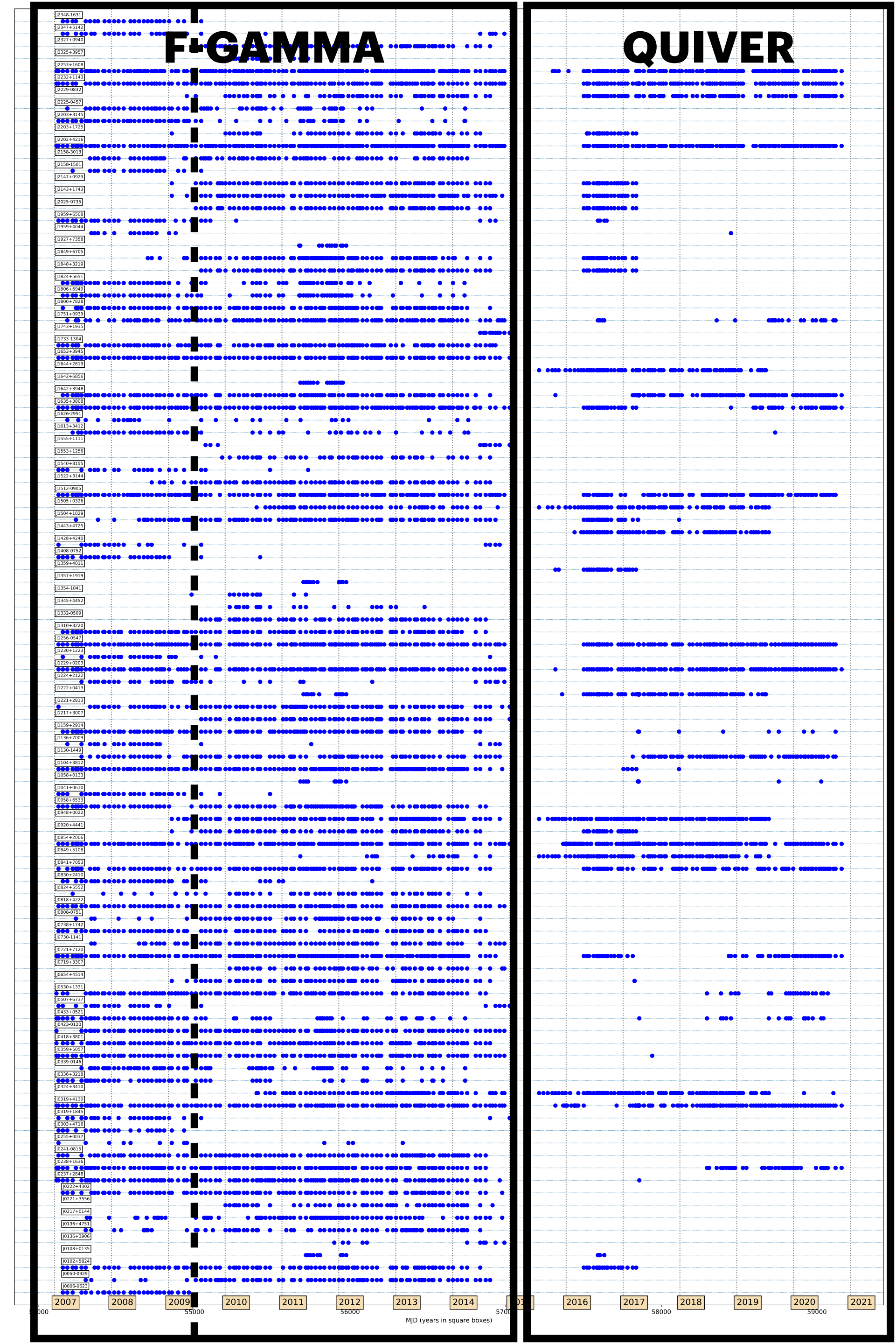
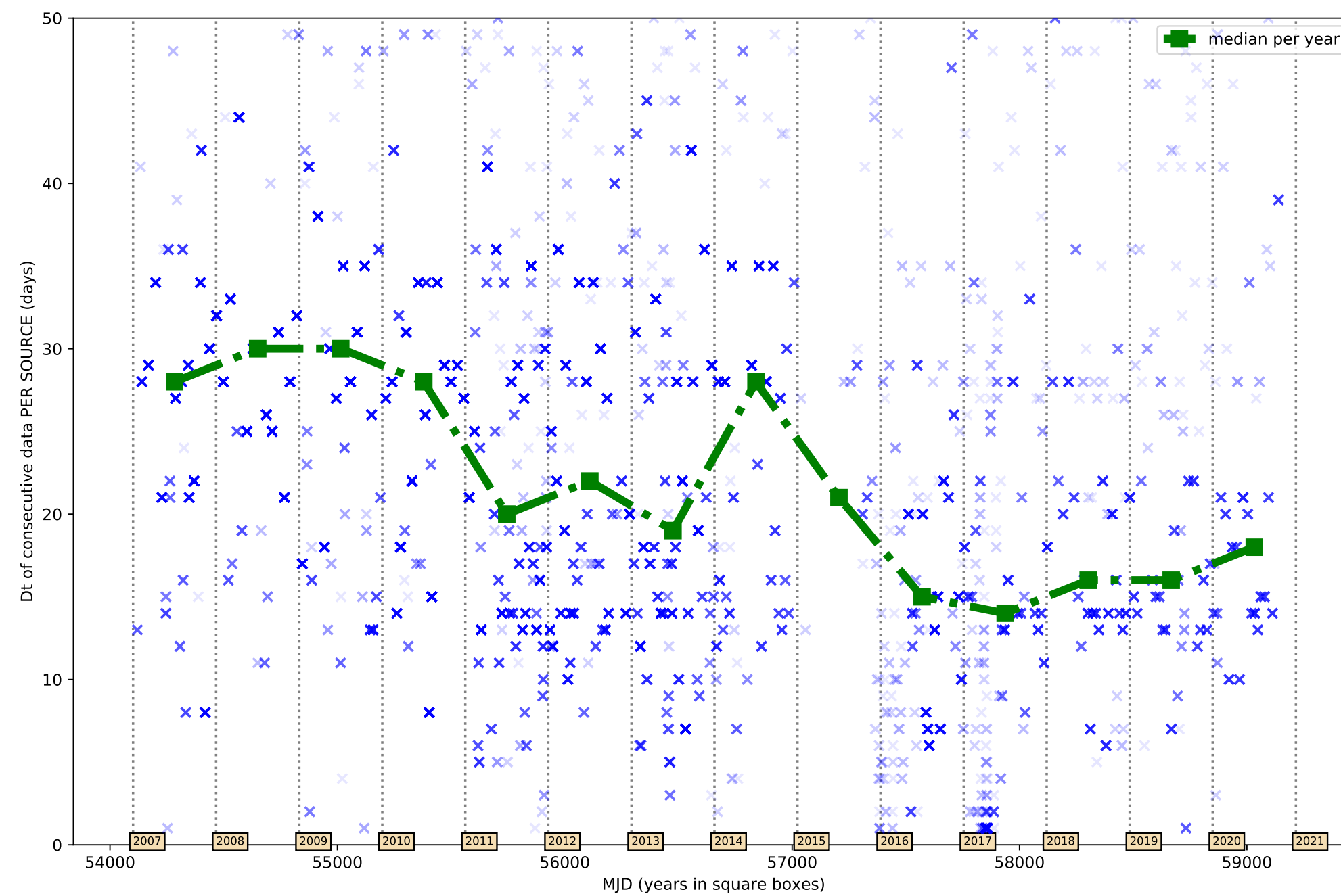
Number of sources

- F-GAMMA | 2007 - 2015
 - ~60-70 sources monitored at all times
 - 30 sources replaced around 2009.5
- QUIVER | 2015 - now
 - ~20 sources (always the same)
 - most polarized and variable



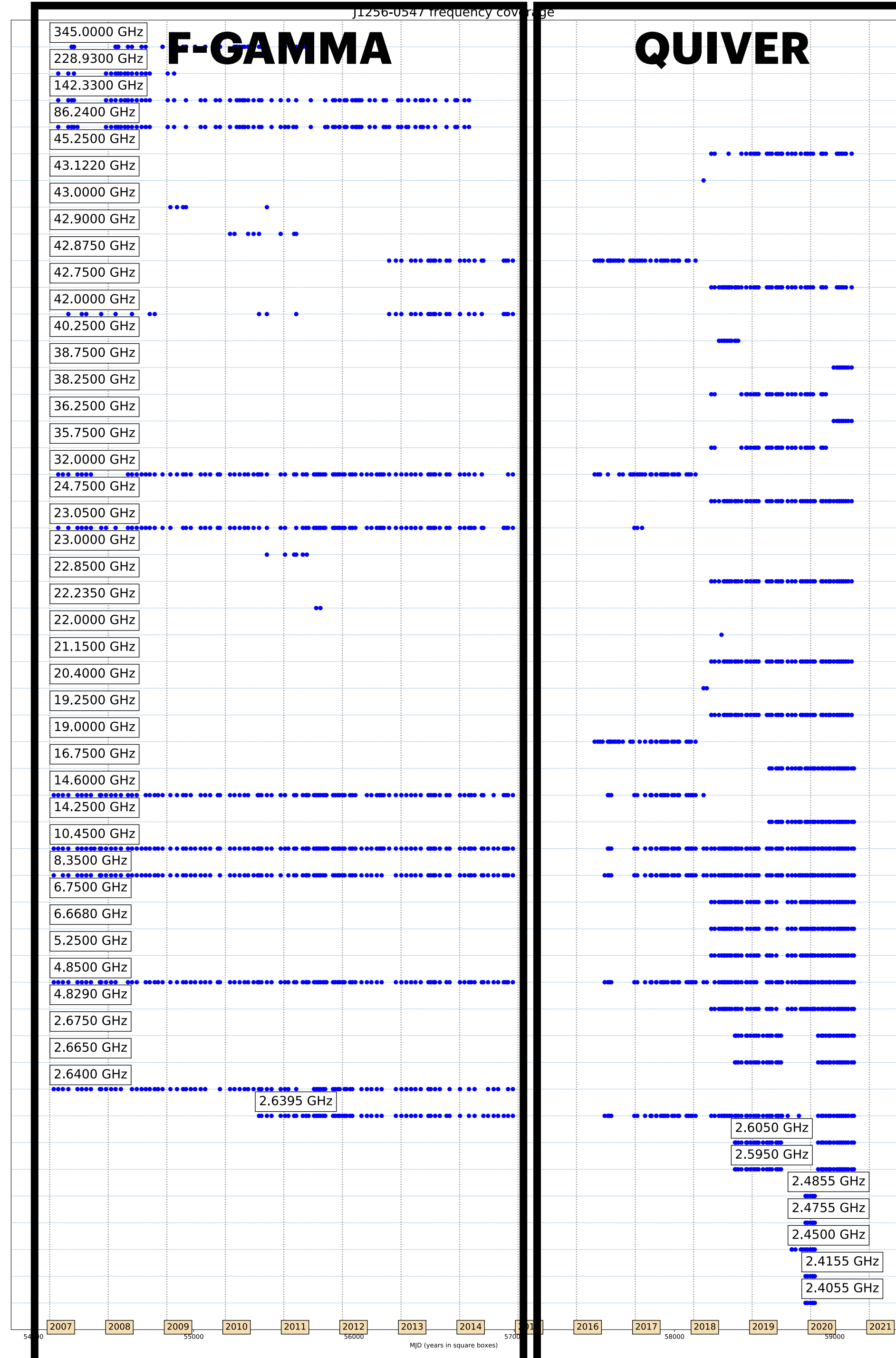
Cadence

- F-GAMMA | 2007 - 2015
 - monthly for all sources
 - 2011 - 2015: biweekly for a subset of “fast” sources
- QUIVER | 2015 - now
 - biweekly
 - resolving n-pi ambiguity in polarization plane rotations



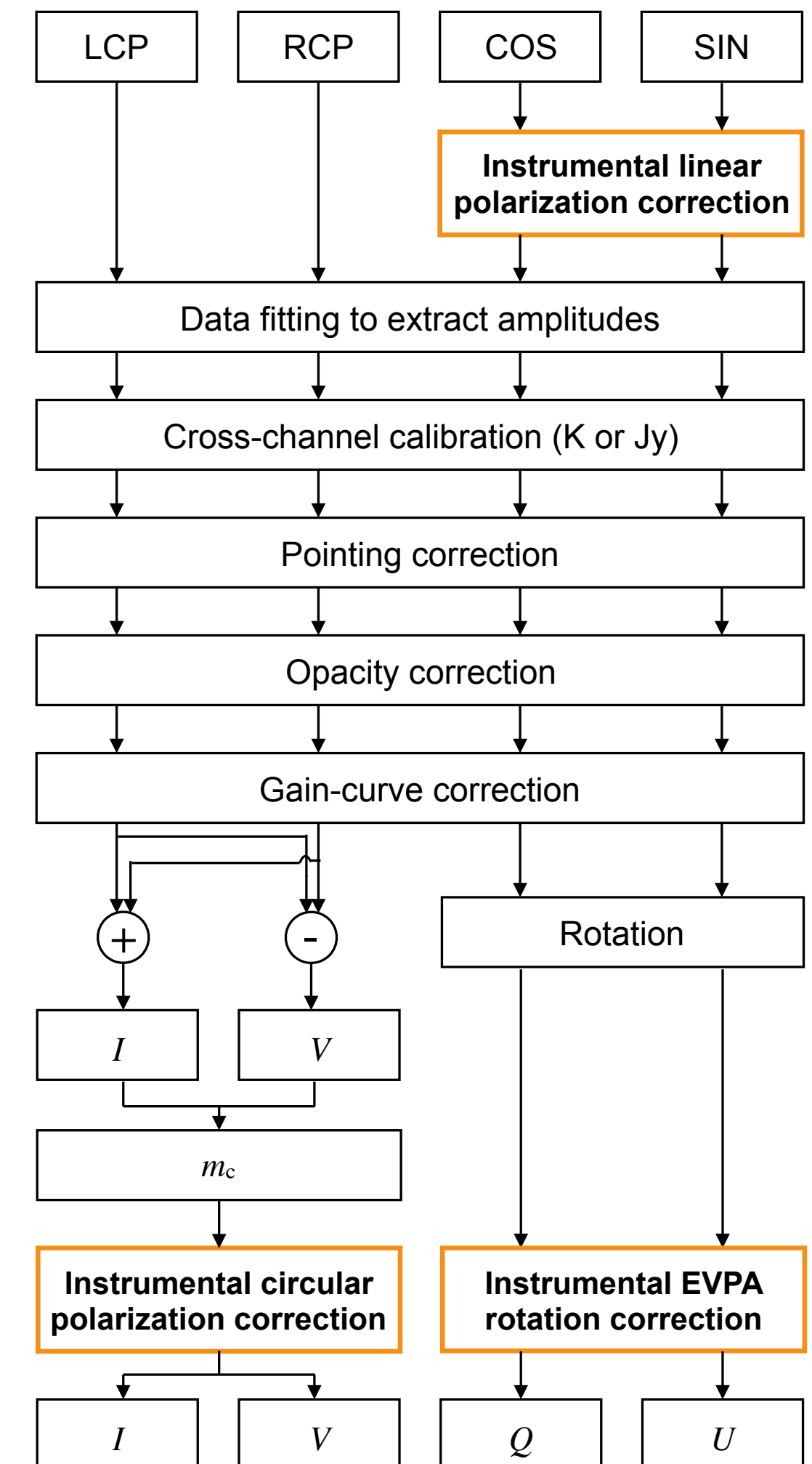
Frequency coverage

- Effelsberg 100-m
 - 2.5 - 45 GHz (8 bands) | 2007 - 2018
 - 2.5 - 45 GHz (9 bands - 22 sub-bands) | 2018 - 2020
 - better RFI mitigation
 - intraband studies, e.g. RM (synthesis)
 - SPECPOL backend
- IRAM 30-m
 - 86 - 230 GHz (3 bands) | 2007 - 2014.5
- APEX 12-m
 - 345 GHz (1 band) | 2007 - 2011.5



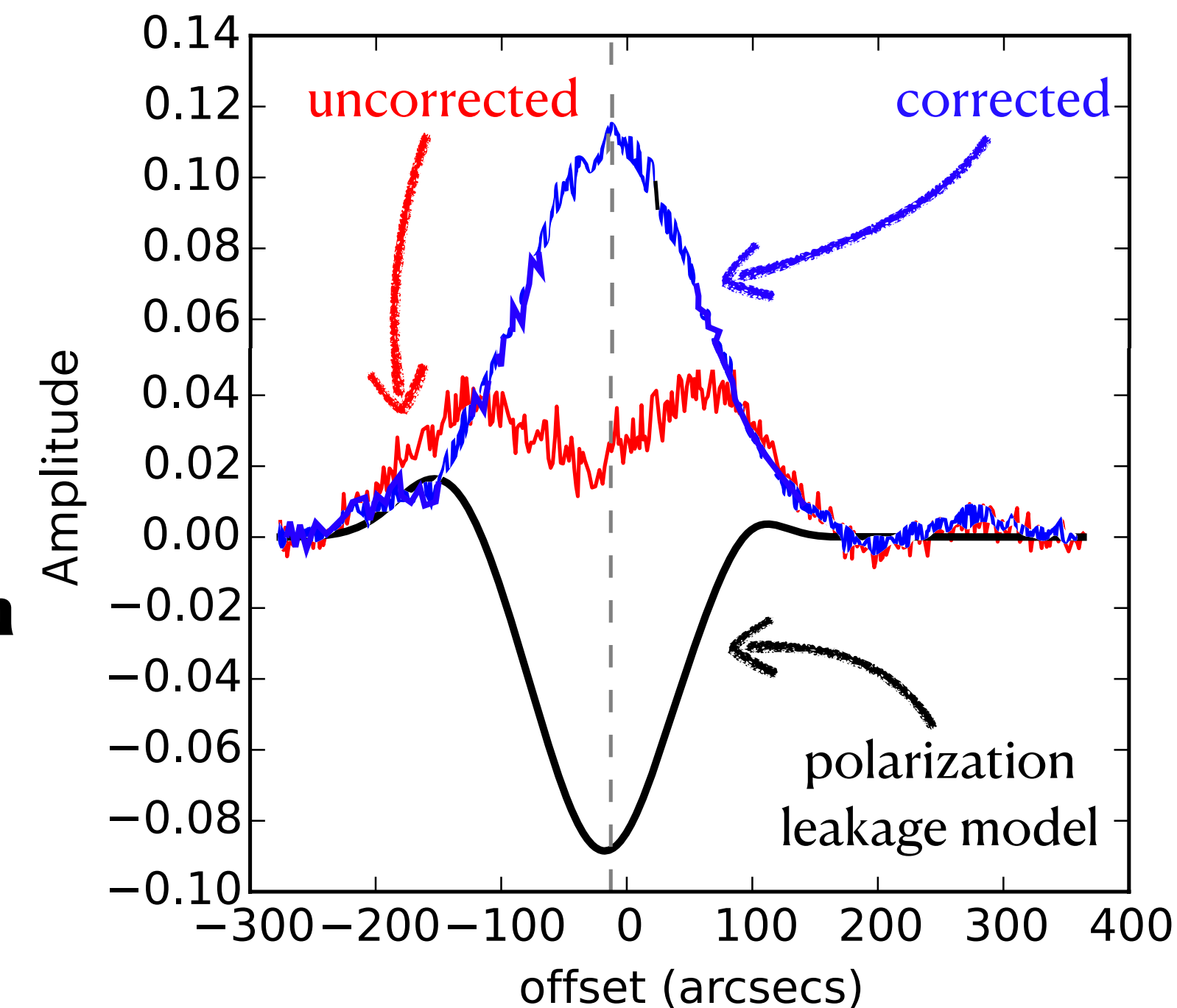
High precision, linear and circular polarimetry

- complete pipeline
 - from telescope observables to I, Q, U, V
 - designed for CP feeds but easily applicable also to LP feeds
- several correction steps (general & polarization-specific)
 - pointing, opacity, elevation-dependent gain
 - airy disk instead of gaussian beam pattern
- minimization of instrumental effects:
 - instrumental linear polarization correction **across the telescope beam**
 - absolute EVPA calibration with **Lunar** observations
 - instrumental circular polarization correction with **two** independent methods
- polarimetric precision:
 - linear & circular polarization degree: **0.1–0.2 %**
 - polarization angle (EVPA): **1°**



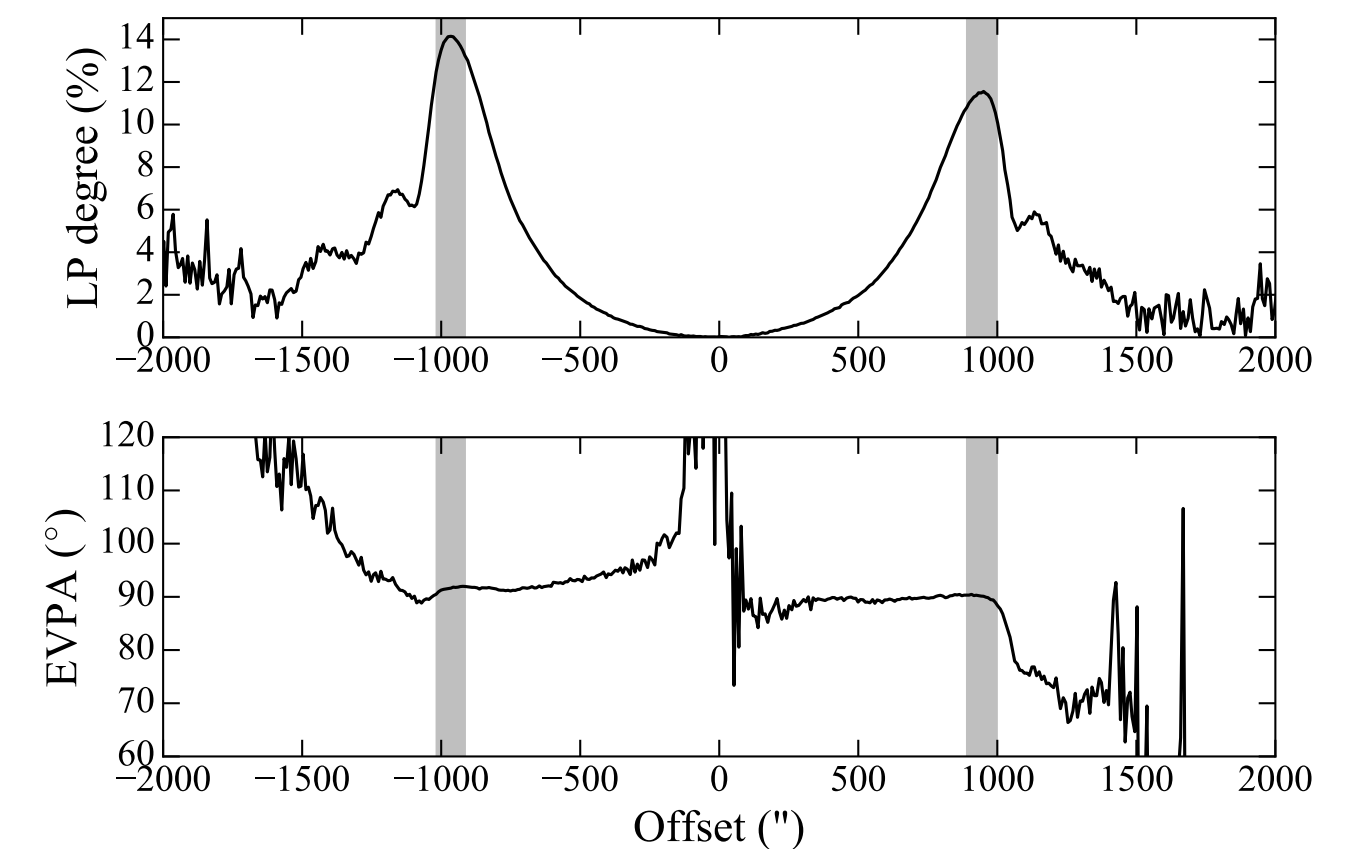
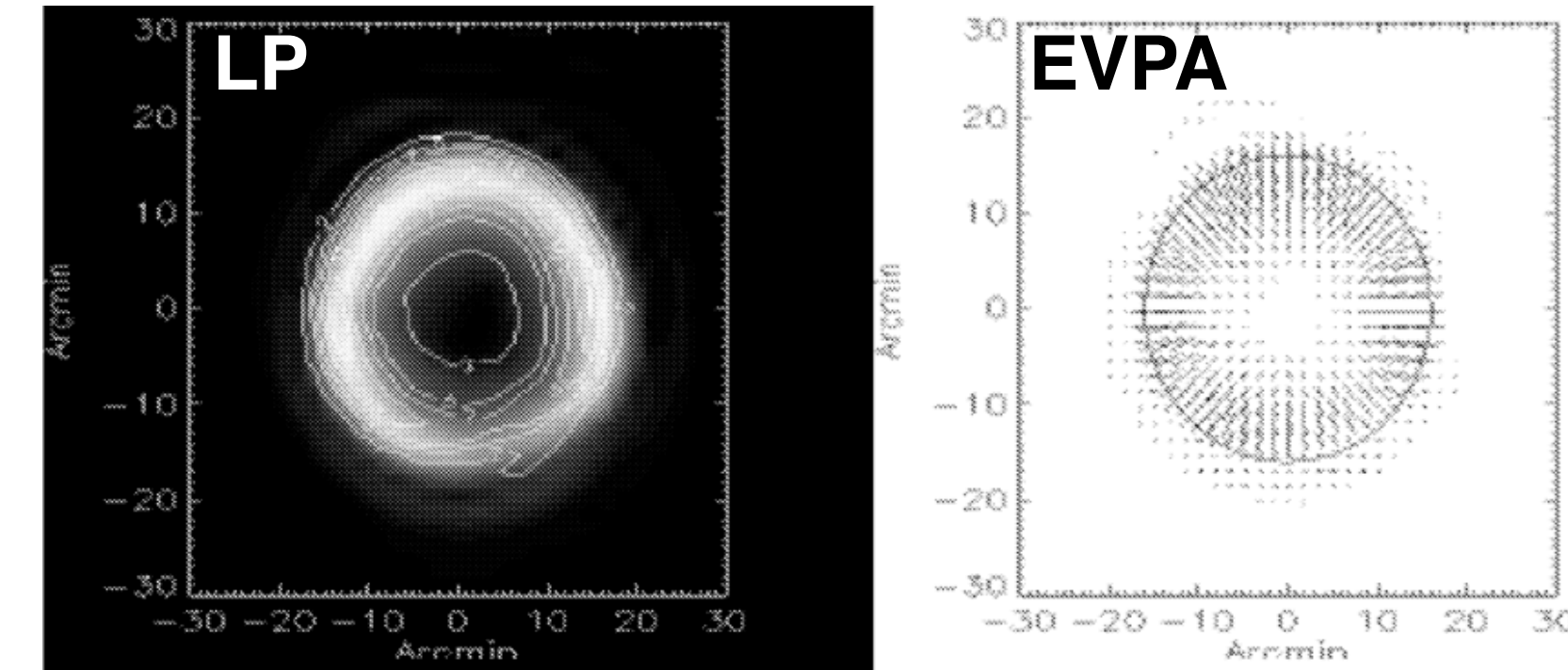
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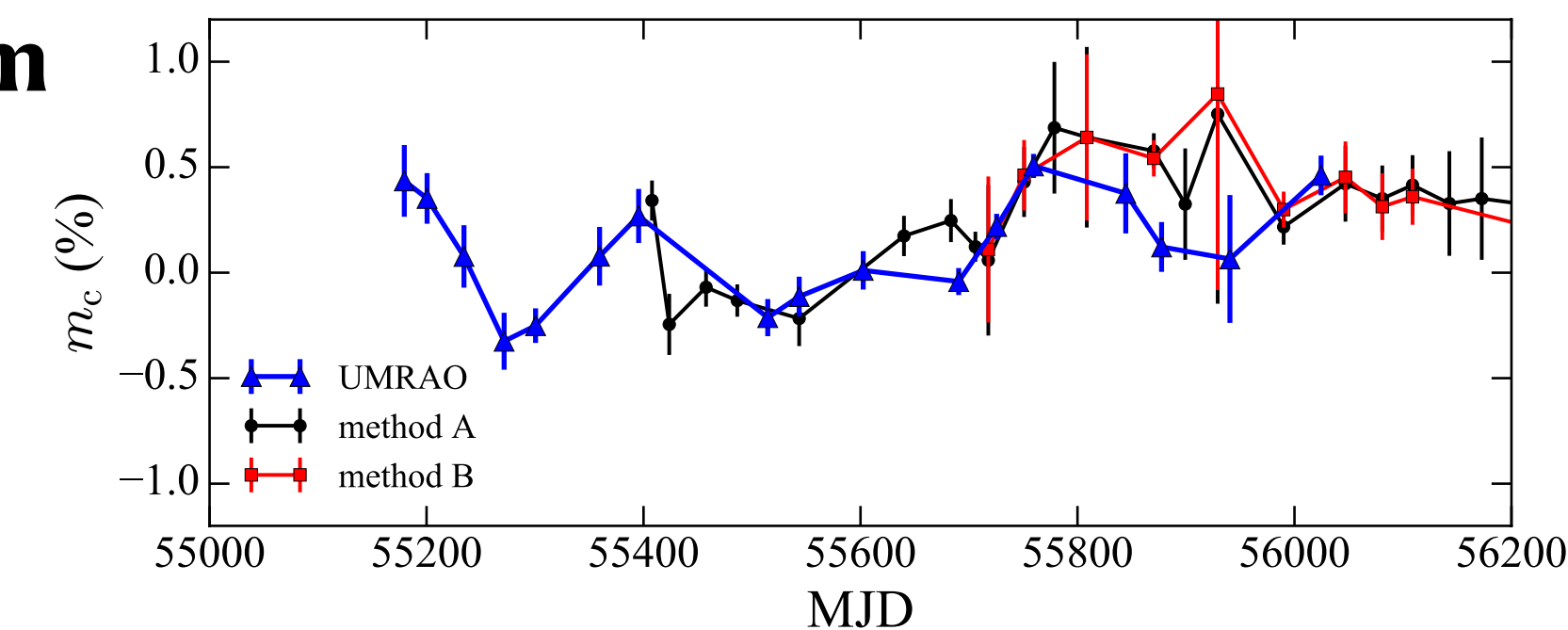
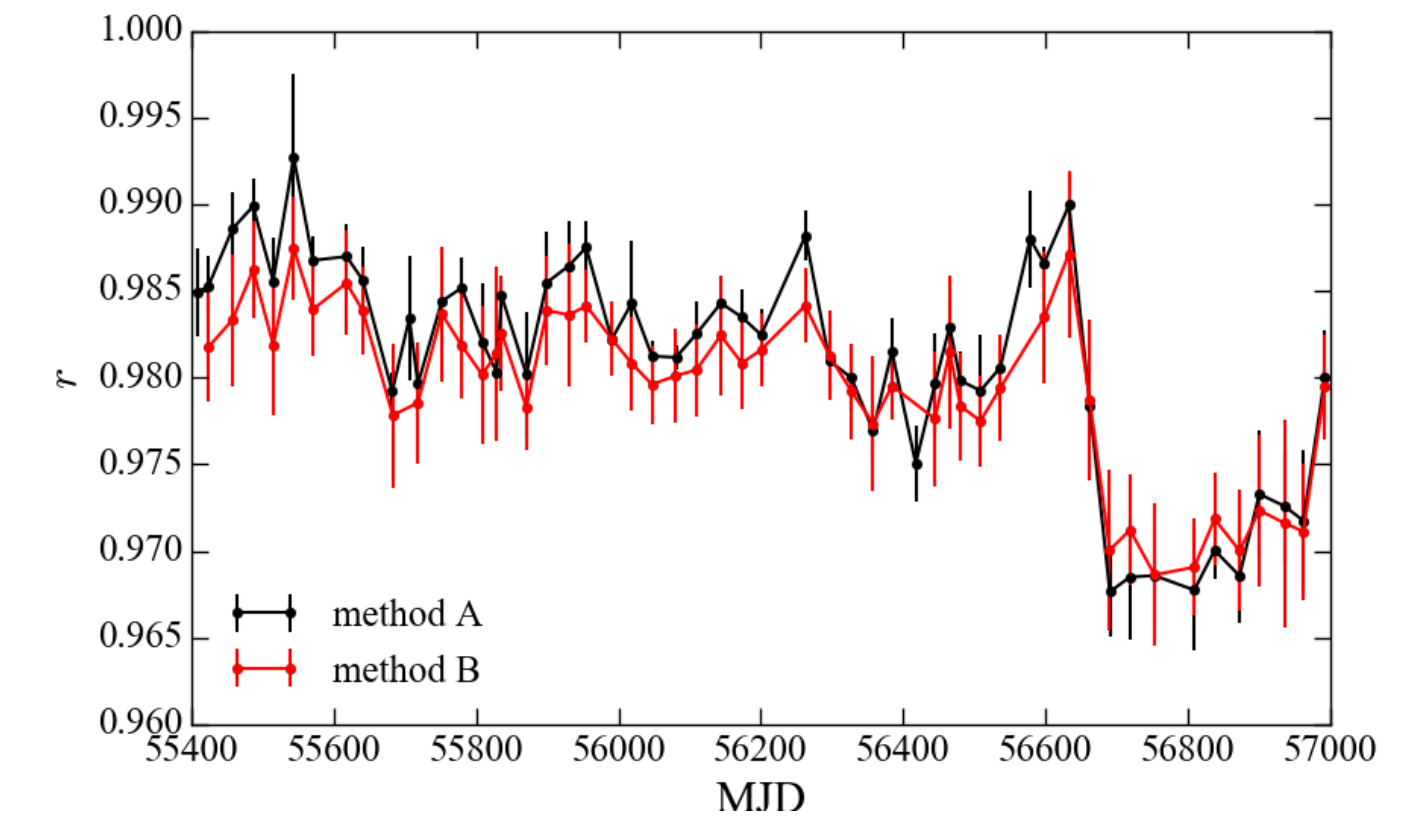
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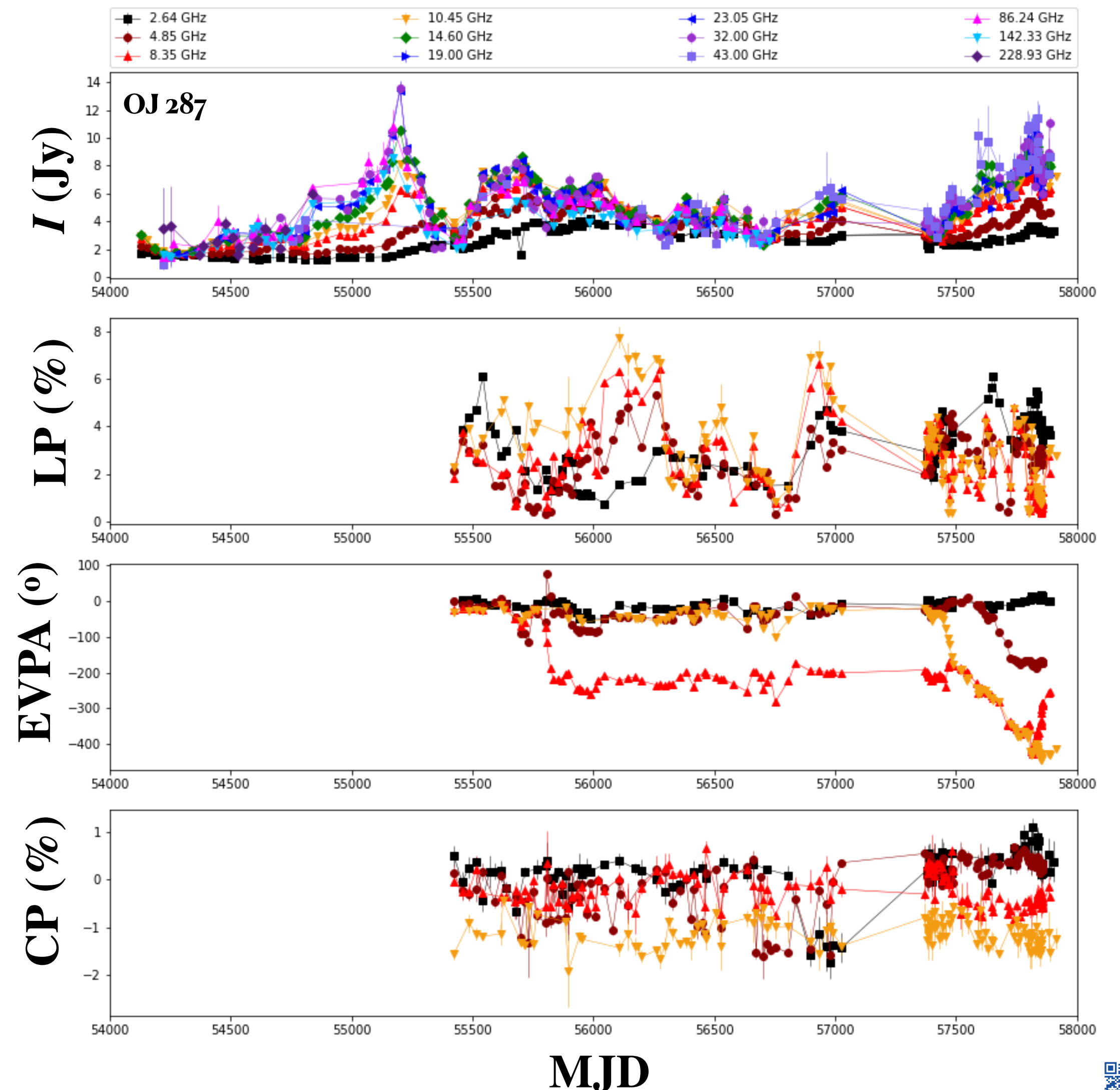
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Multi-frequency total flux and polarization monitoring

- F-GAMMA + QUIVER monitoring programs
 - since Jan 2007
 - total of ~100 sources (mostly *Fermi* blazars)
 - mean cadence ~ 20 days
 - 2.64–345 GHz at multiple frequency steps
- high-cadence, full-Stokes light curves
 - LP at 2.64, 4.85, 8.35, 10.45 and 14.6 GHz
 - CP at 2.64, 4.85, 8.35, 10.45, 14.6, 23.05 GHz
 - recovered data since 2010.5



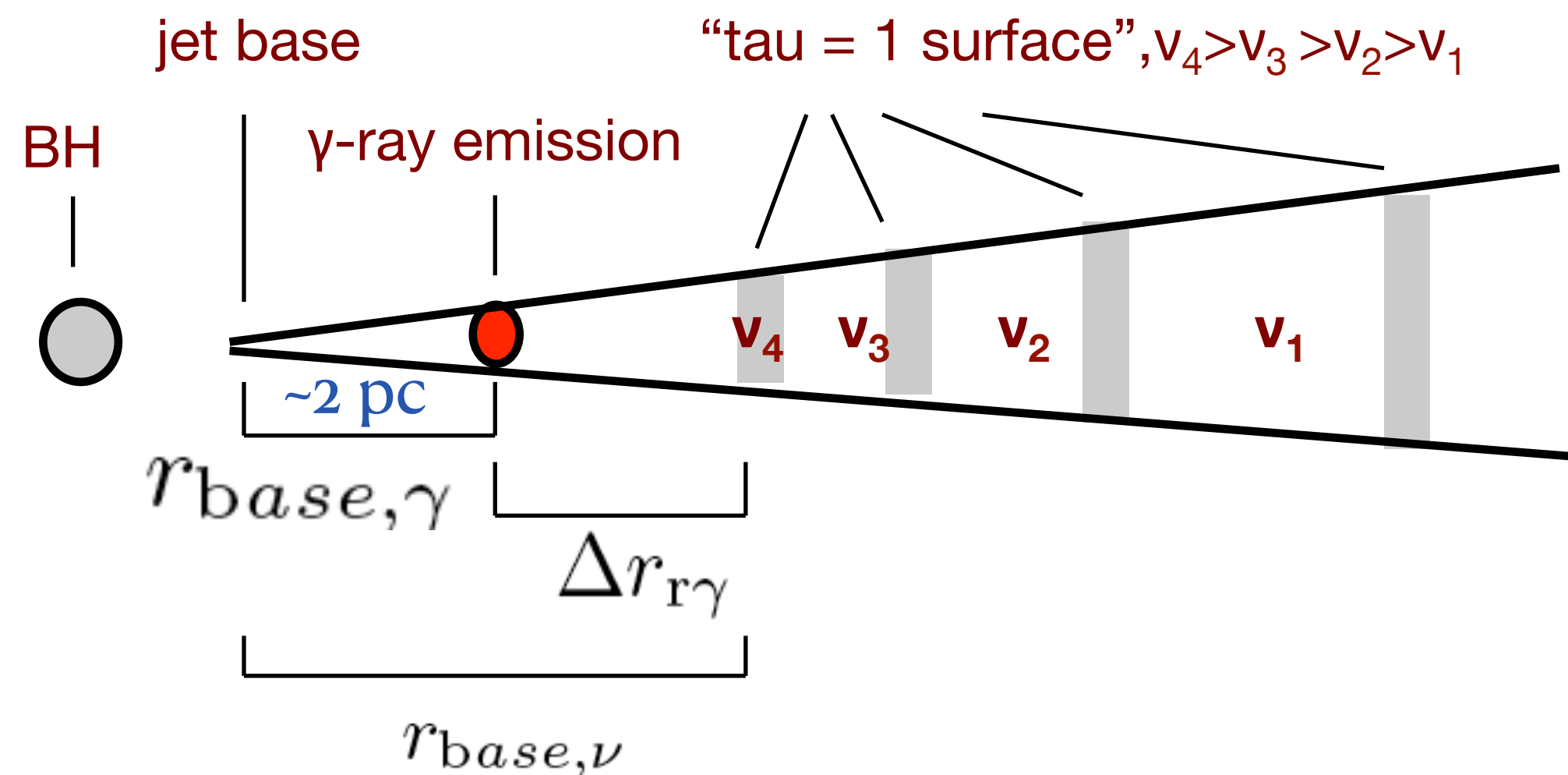
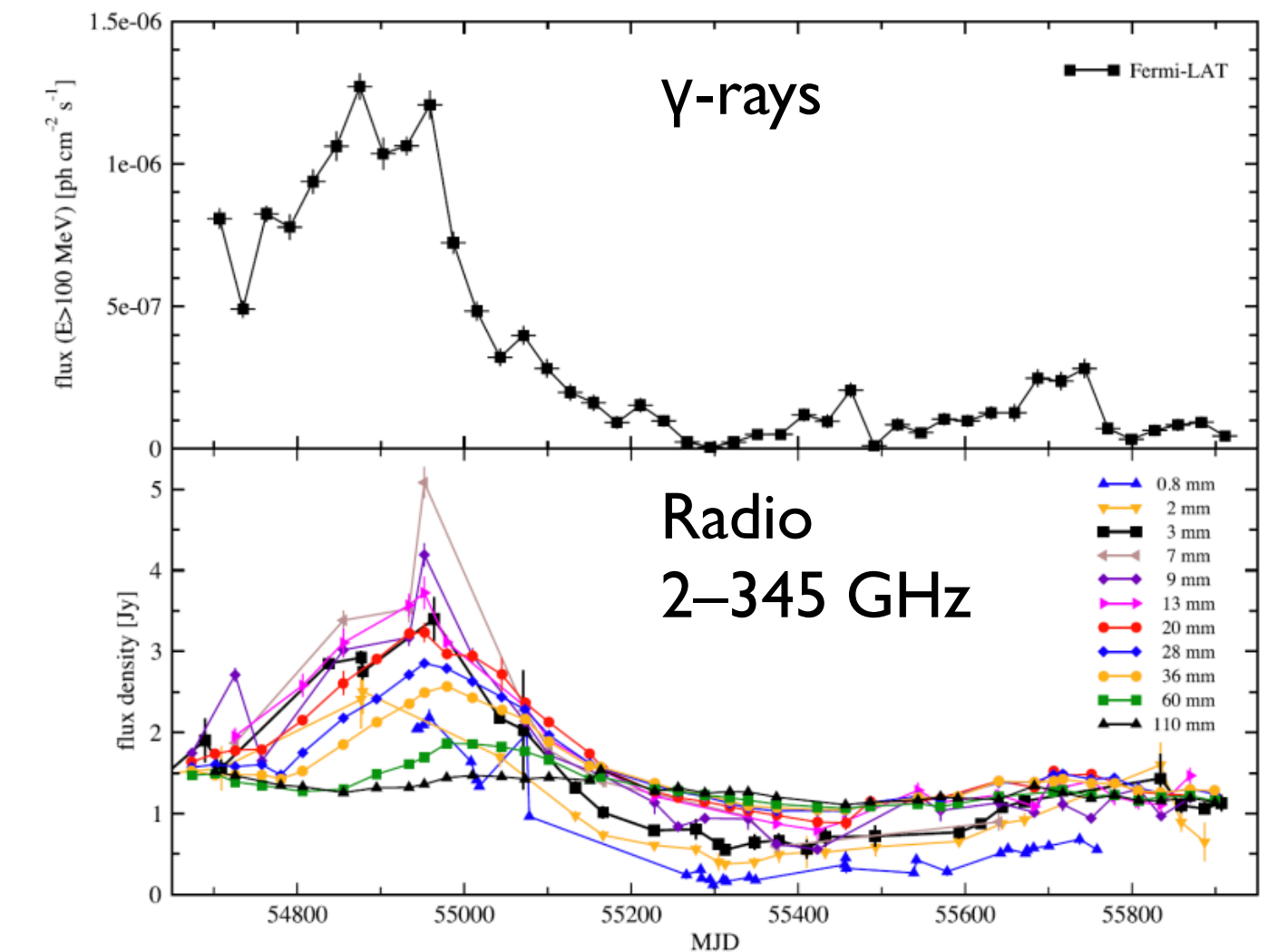
MJD



Locating the γ -ray emission site

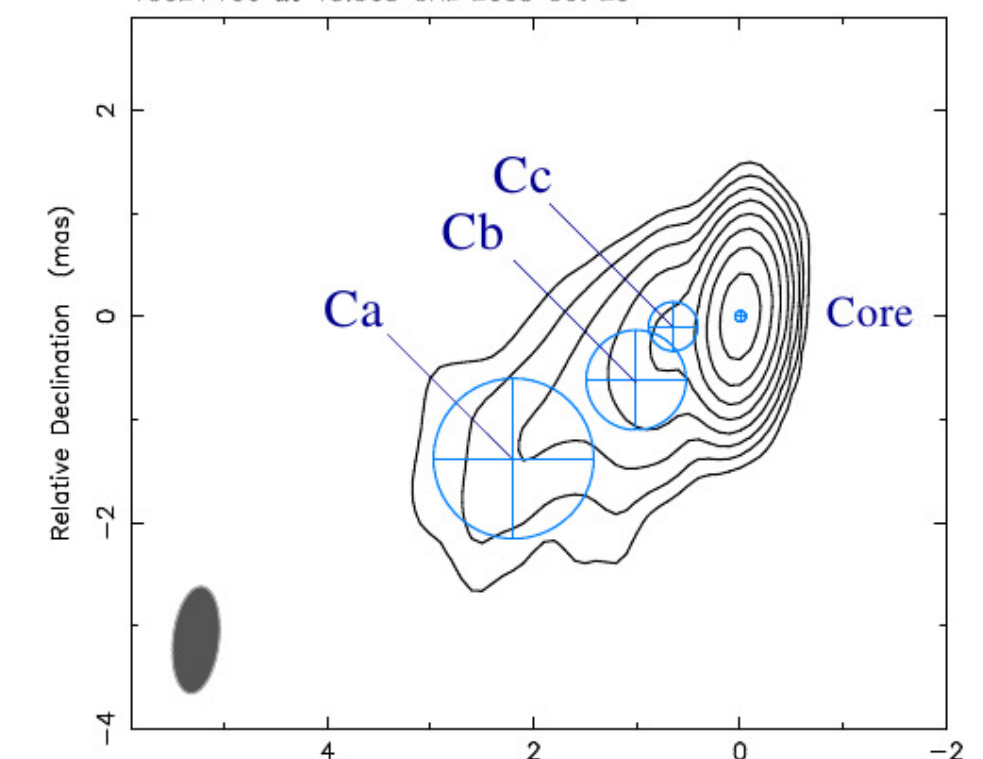
using multi-frequency variability in total flux (Stokes I)

- source: PKS 1502+106
- delay origin: opacity of the synchrotron self-absorbed jet
- relative timing of flare maxima (DCCCF) & knot kinematics (mm-VLBI)
 - precise core-shifts
 - γ -ray emission site



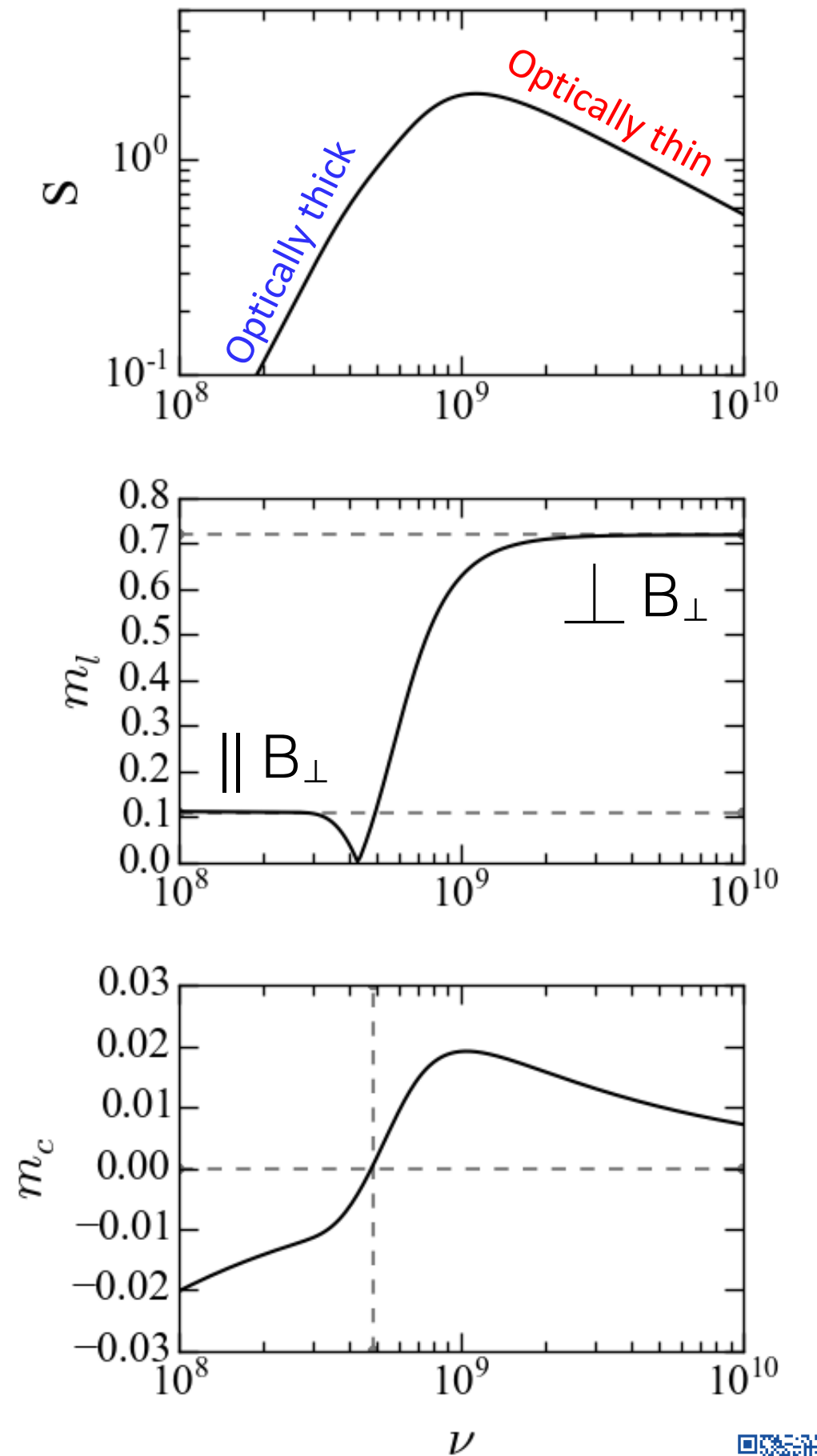
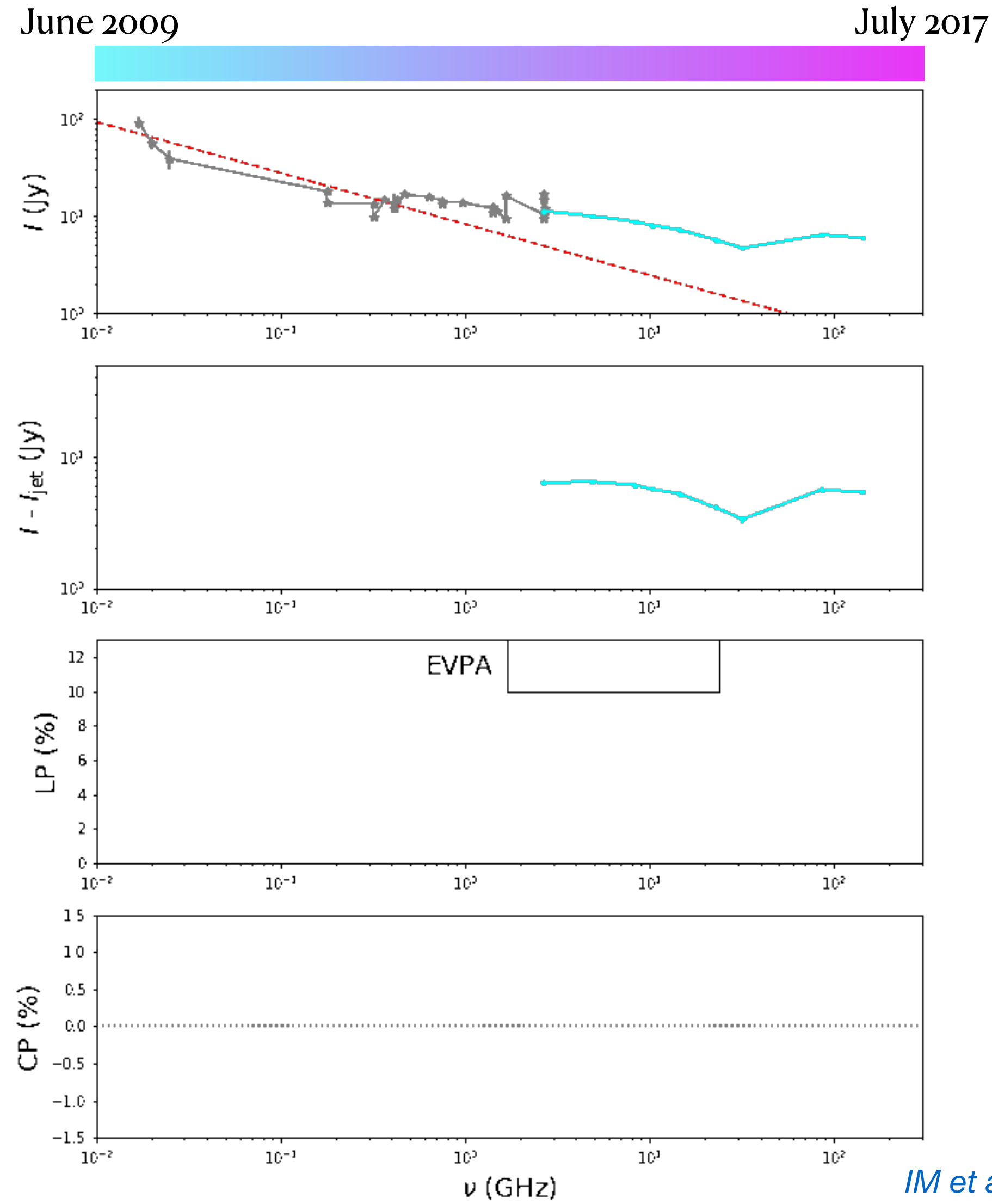
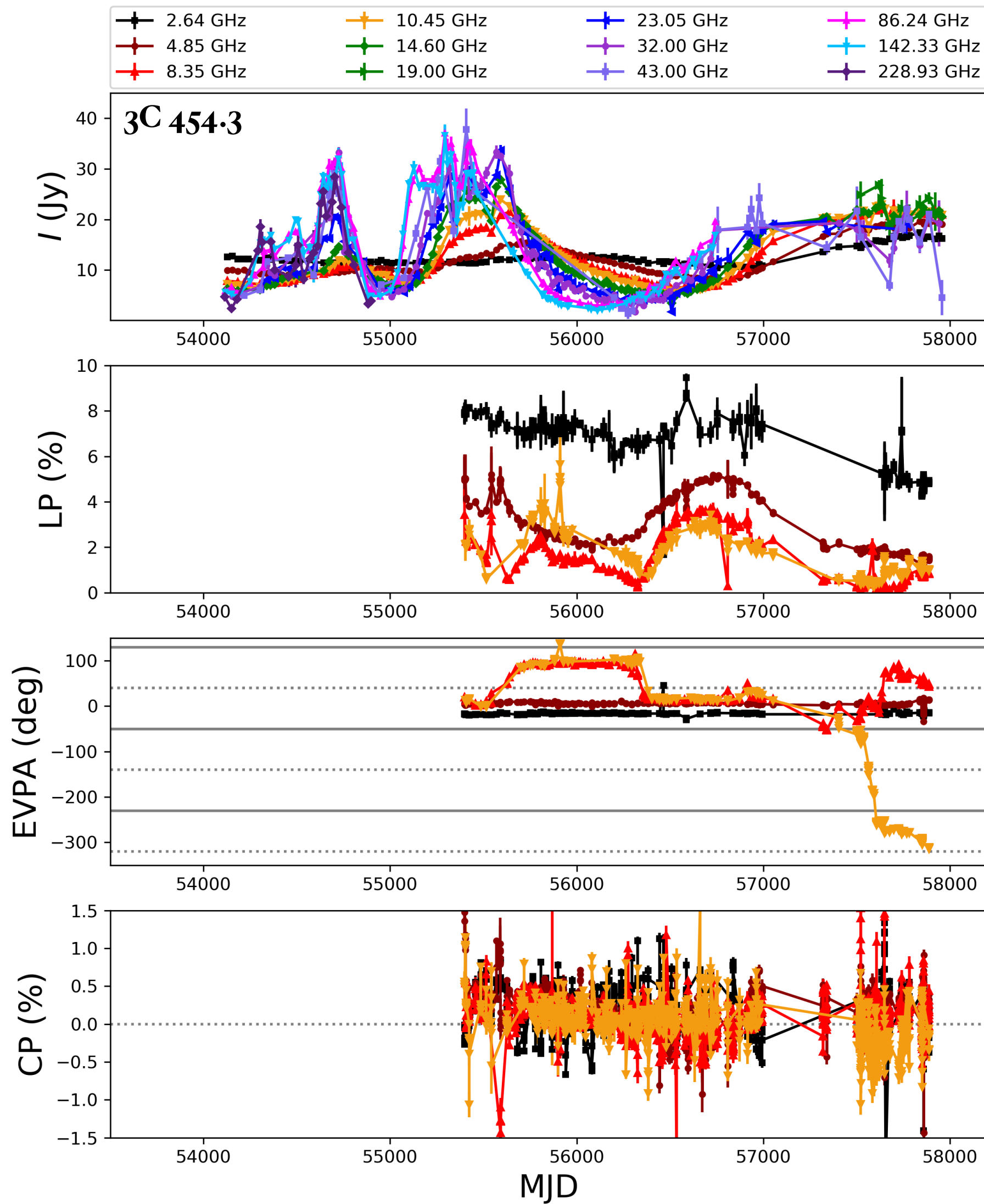
200 days

1502+106 at 15.365 GHz 2005 Oct 29



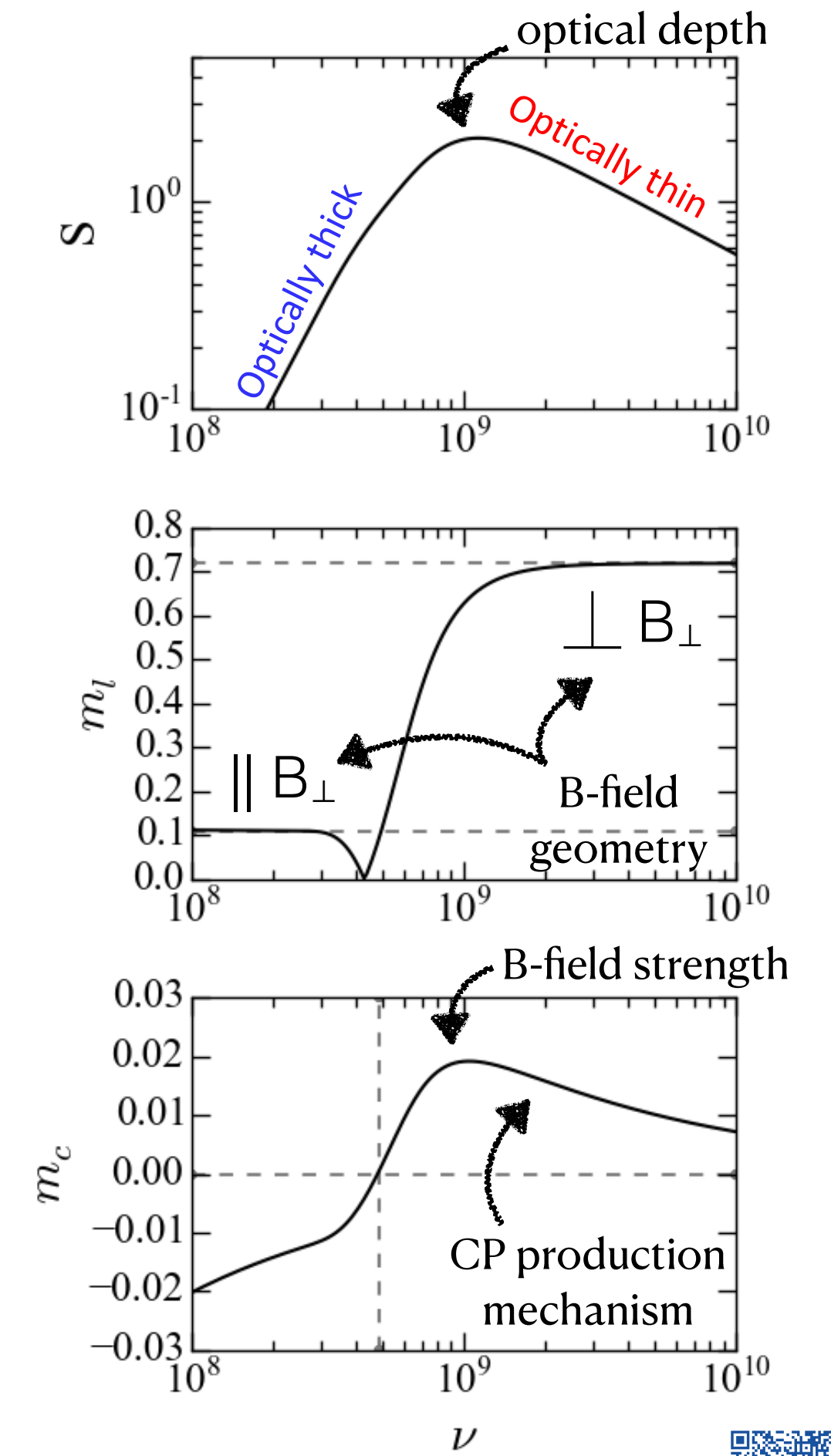
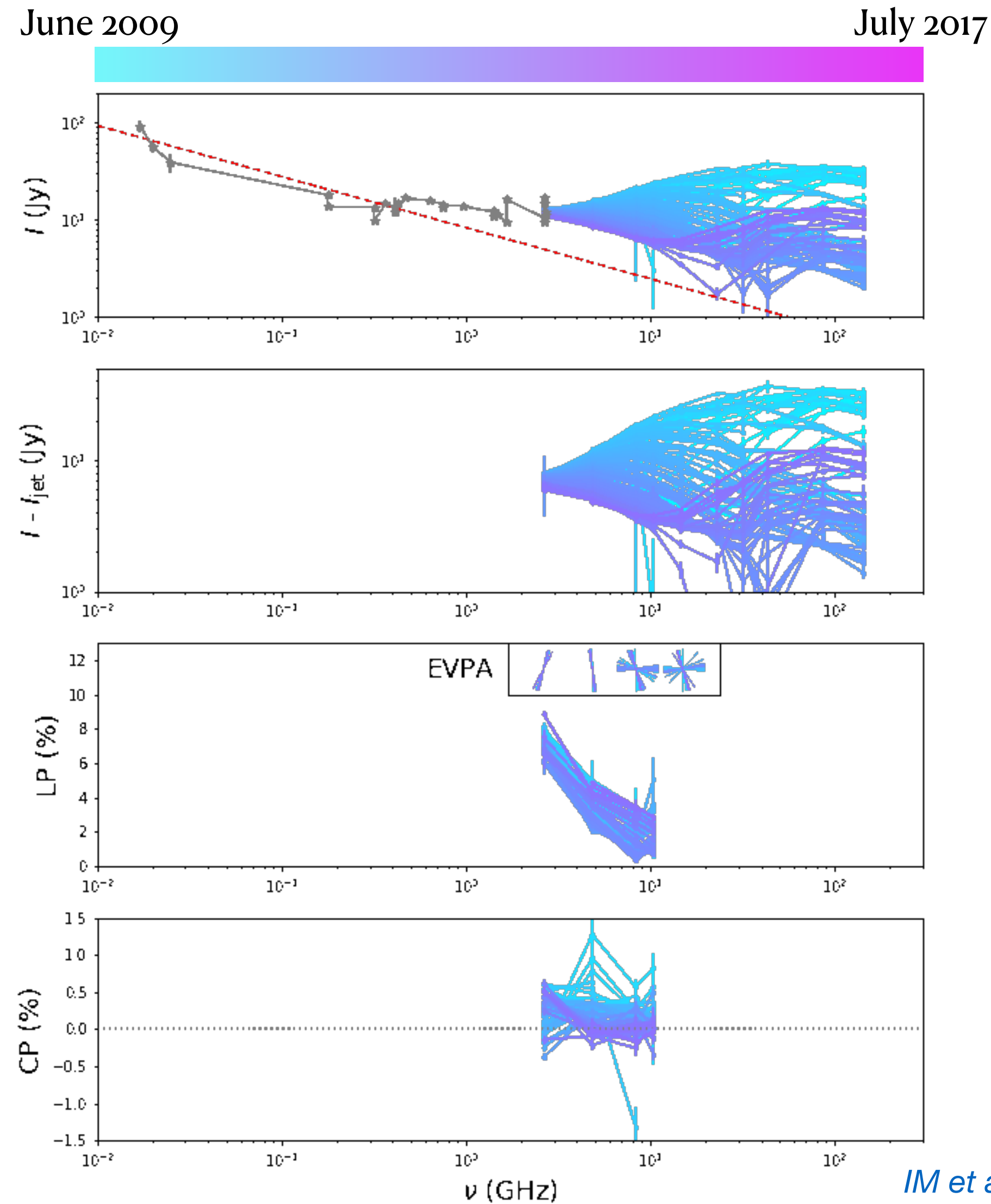
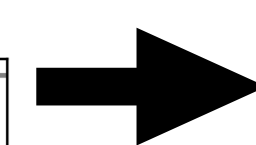
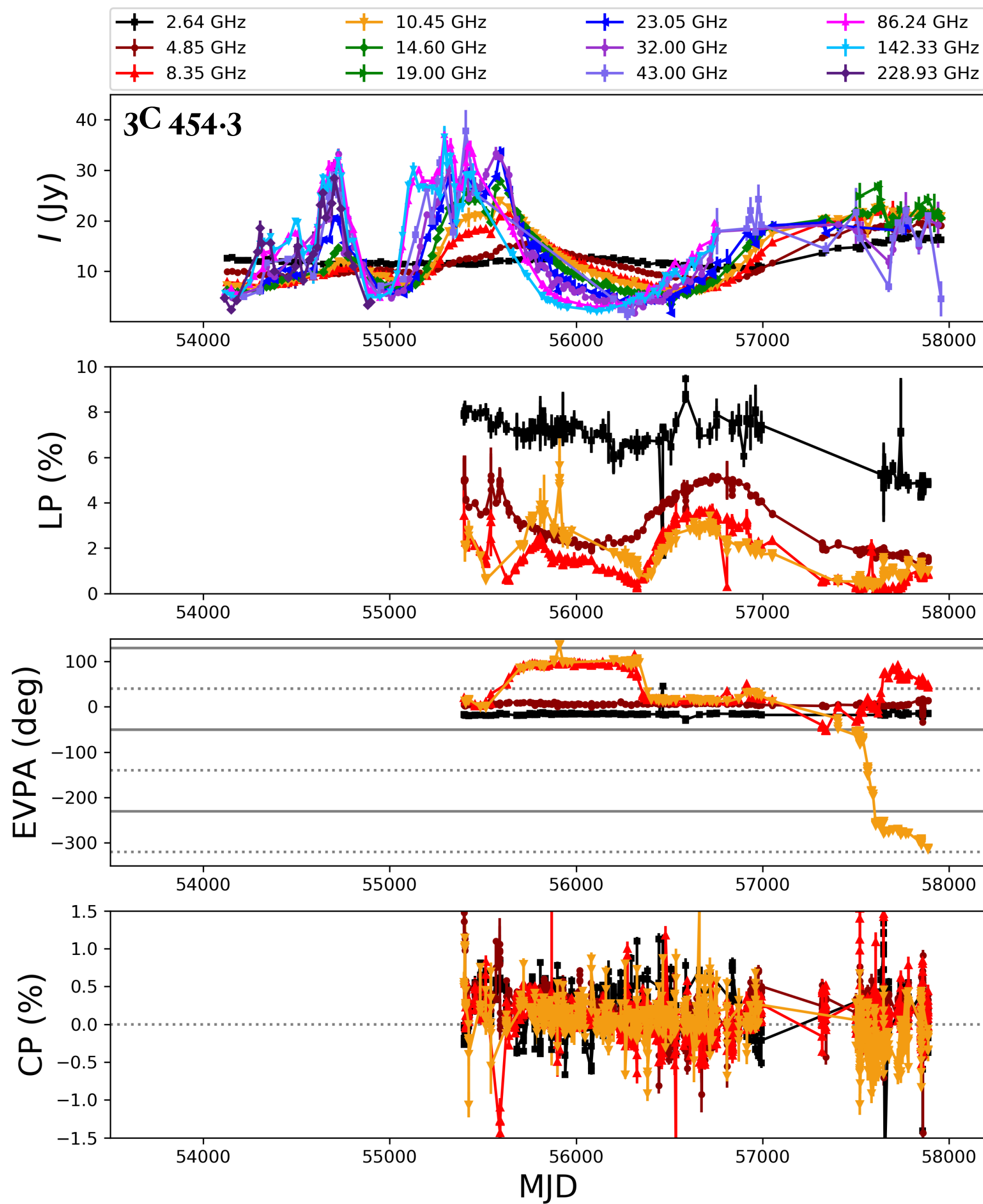
Constraining physical conditions and variability mechanisms

using multi-frequency variability in total flux, linear and circular polarization (Stokes I , Q , U & V)



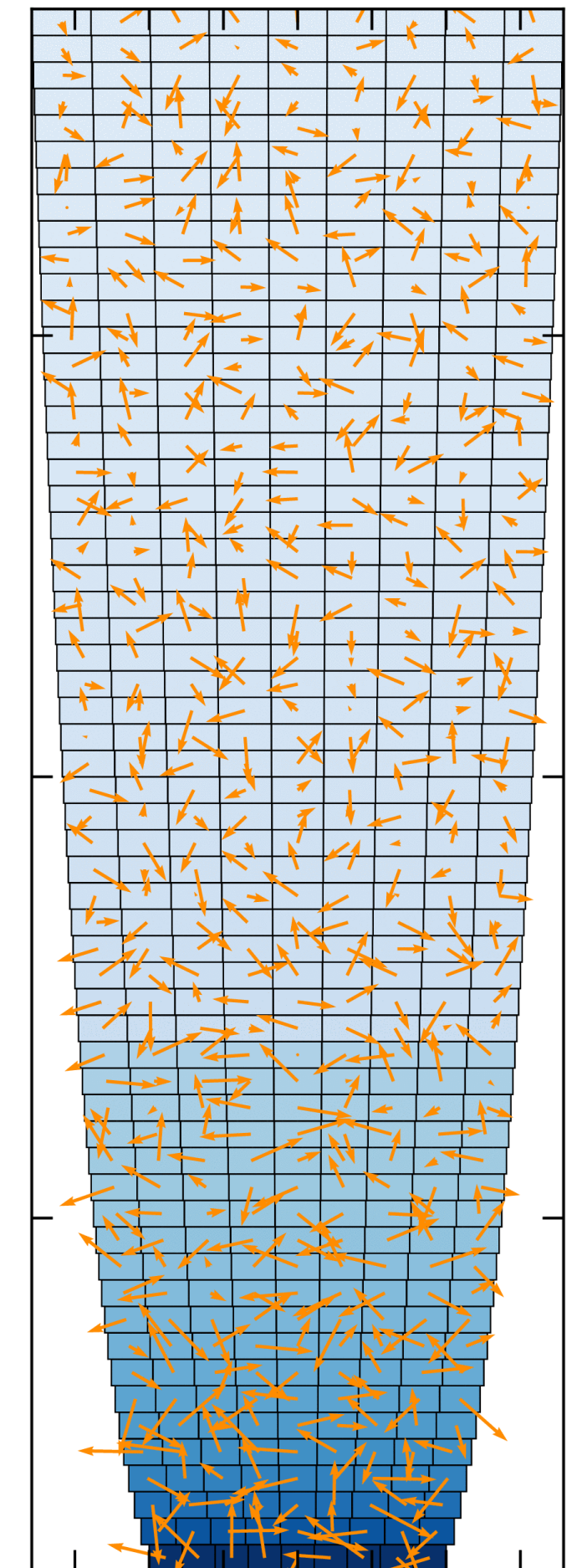
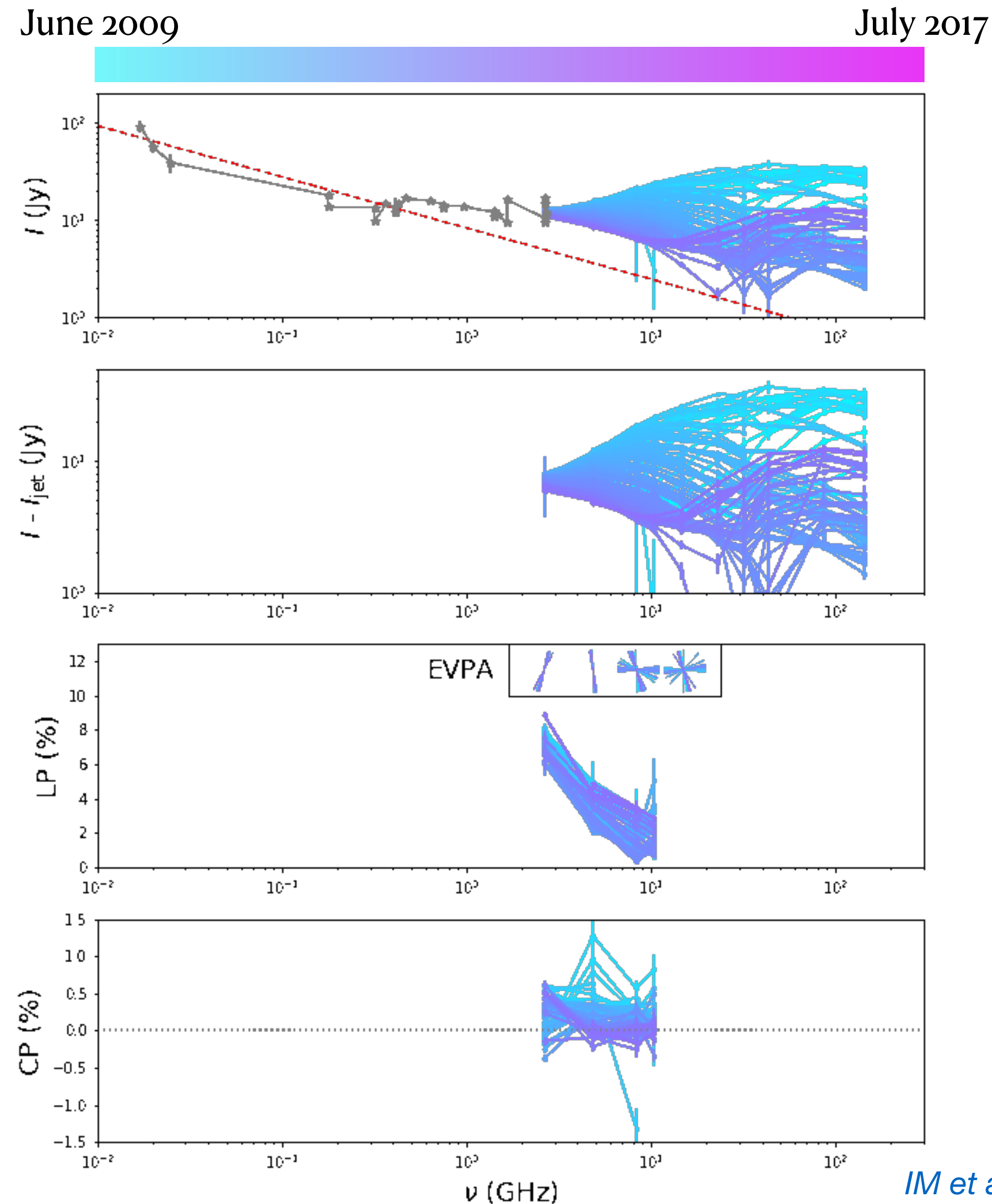
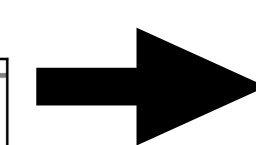
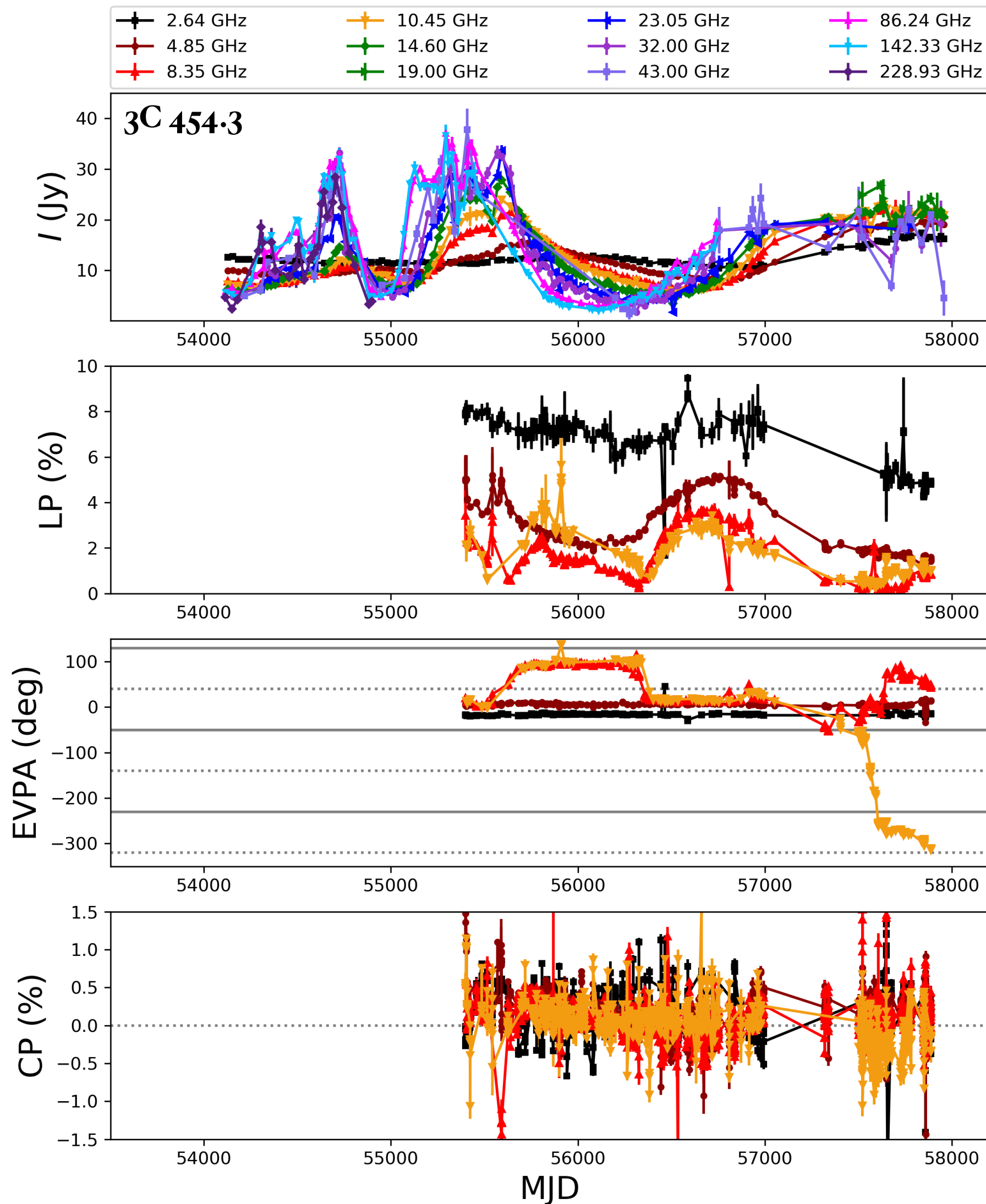
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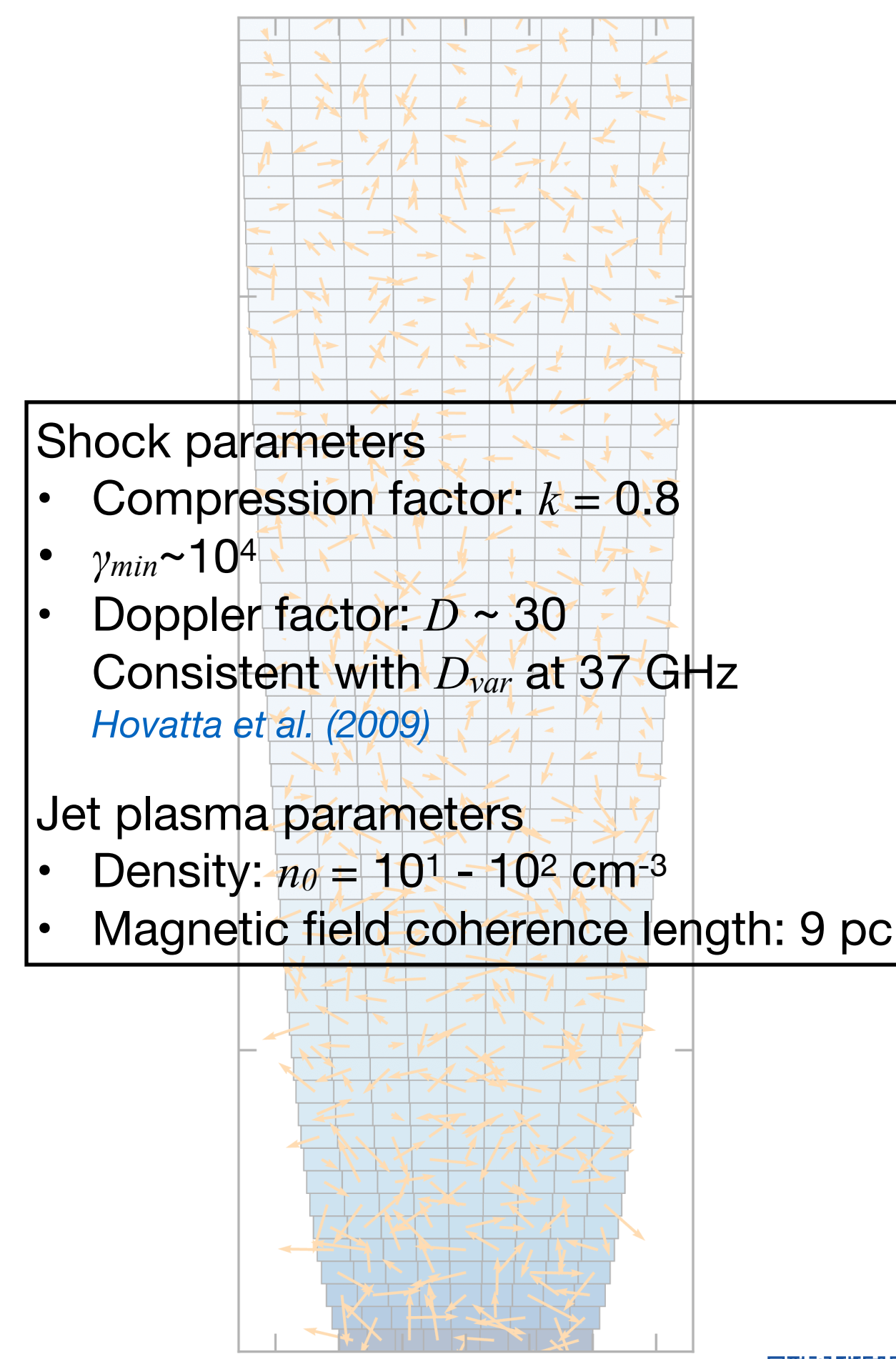
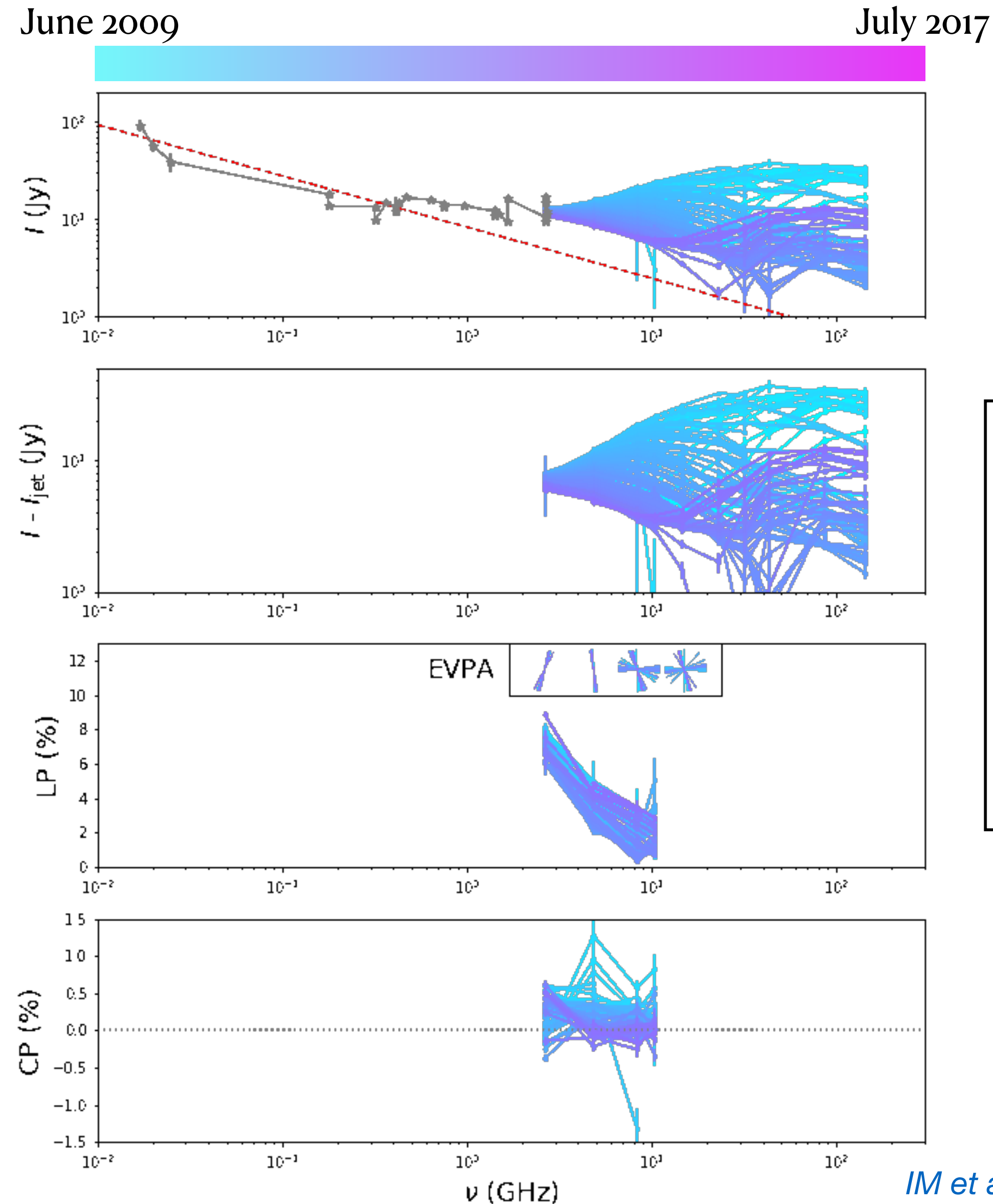
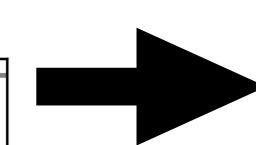
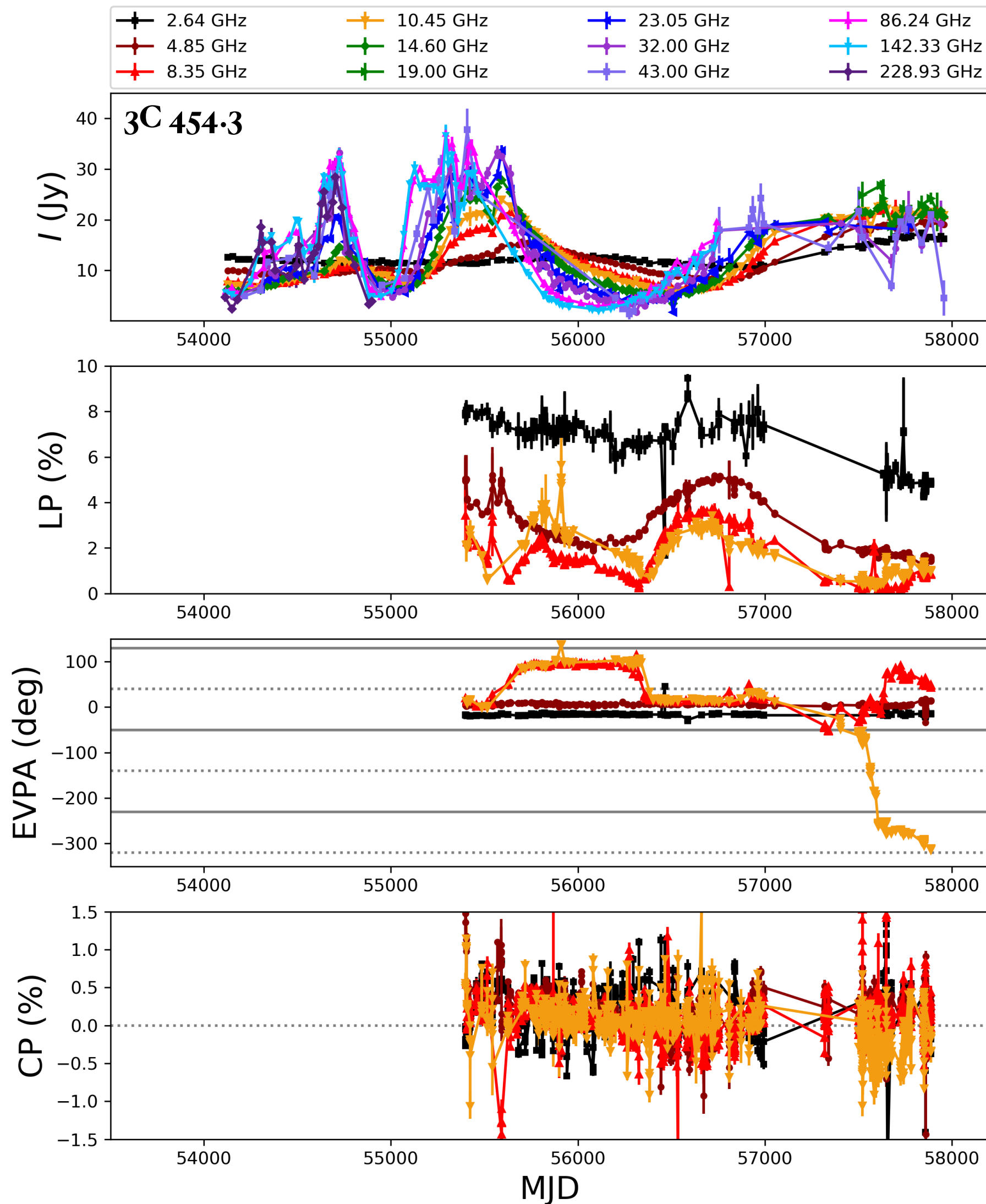
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Constraining physical conditions and variability mechanisms

using multi-frequency variability in total flux, linear and circular polarization (Stokes I , Q , U & V)



- Shock parameters**
- Compression factor: $k = 0.8$
 - $\gamma_{min} \sim 10^4$
 - Doppler factor: $D \sim 30$
 - Consistent with D_{var} at 37 GHz
 - [Hovatta et al. \(2009\)](#)
- Jet plasma parameters**
- Density: $n_0 = 10^1 - 10^2 \text{ cm}^{-3}$
 - Magnetic field coherence length: 9 pc



Summary

- F-GAMMA (2007 - 2015) & QUIVER (2015 - now) dataset
 - ~100 monitored sources
 - min. cadence: 15 days
 - max. frequency coverage: 2.6 - 345 GHz (lately with several sub-bands)
- High-precision, linear and circular polarimetry
 - linear & circular polarization degree accuracy: 0.1–0.2 %, EVPA accuracy: 1°
- Examples:
 - variability in Stokes I : localizing the gamma-ray emission site in PKS 1502+106
 - variability in Stokes I, Q, U, V : constraining physical conditions and variability mechanisms in 3C 454.3
- For more information & data requests, contact us: imyserlis@iram.es , eangelakis@physics.auth.gr