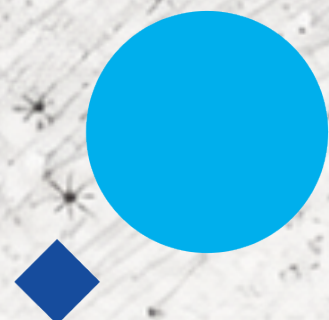
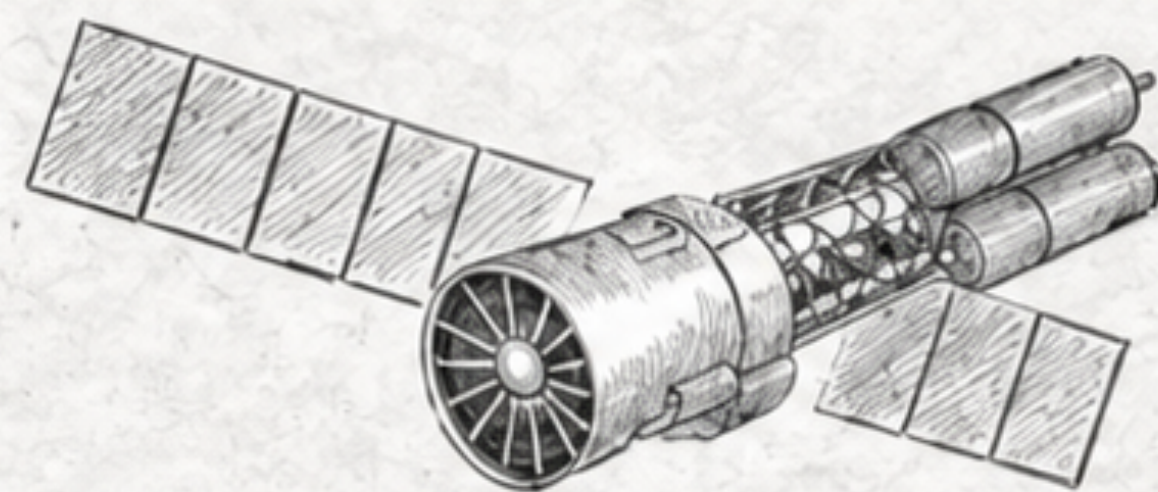




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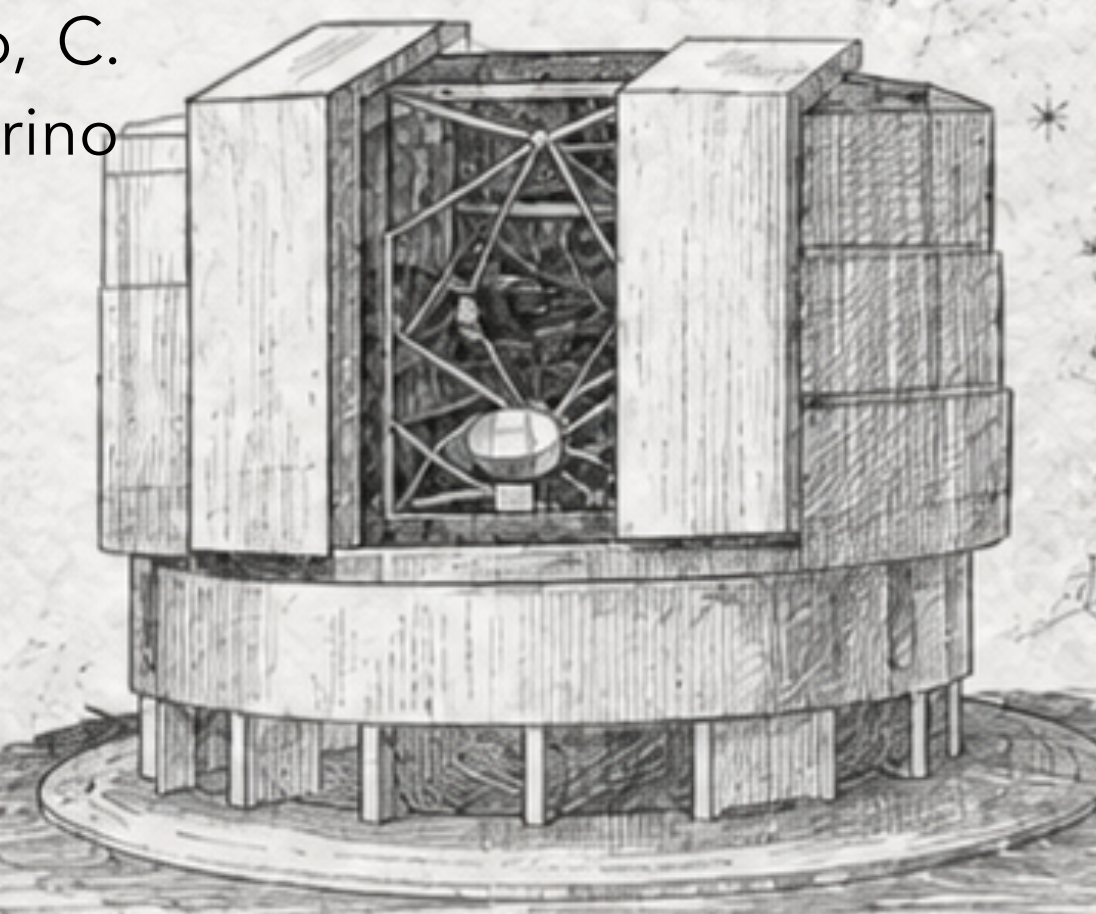
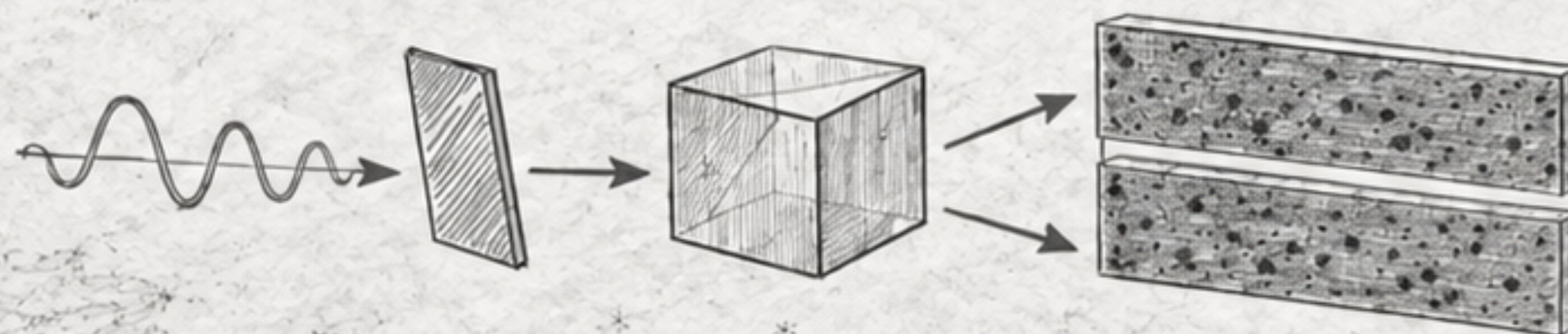
Polarimetry Across the Spectrum

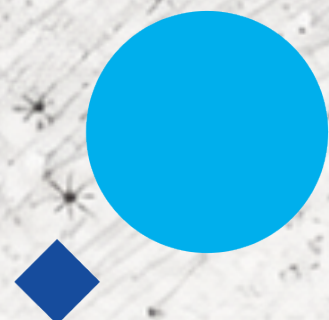
Probing Accretion and Outflows in Black Hole X-ray Binaries

M. Cristina Baglio

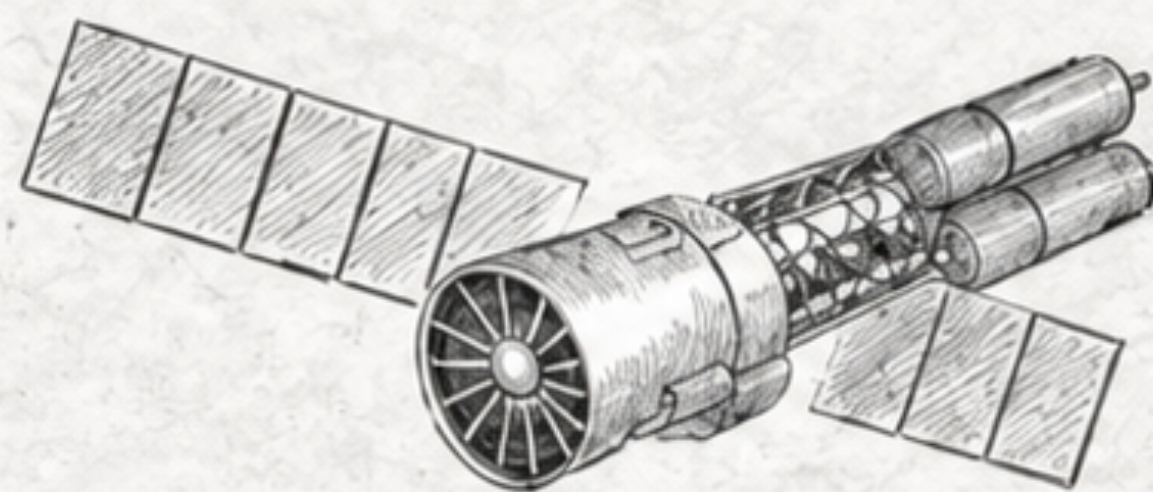
INAF - Osservatorio Astronomico di Brera

(Main) Collaborators: G. Mastroserio (IUSS Pavia), F. Carotenuto, P. Casella (INAF-Roma), S. E. Motta, I. Mariani, C. Salvaggio, K. Alabarta (INAF-OAB), D. M. Russell (NYUAD), G. Illiano (ICE-CSIC), F. Vincentelli (Coventry Univ.), B. De Marco, C. Miceli, Y. Cavecchi (EEBE-UPC), M. Del Santo (INAF-IASF Palermo), A. Marino (USACH), A. Ambrii (IAC), E. V. Lai, M. Bachetti (INAF-OAC), and many more!





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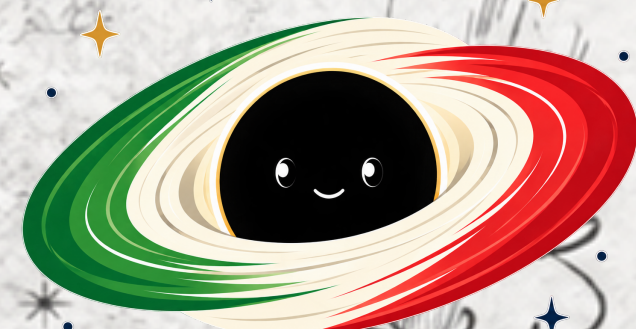


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Polarimetry Across the Spectrum

Probing Accretion and Outflows in Black Hole X-ray Binaries



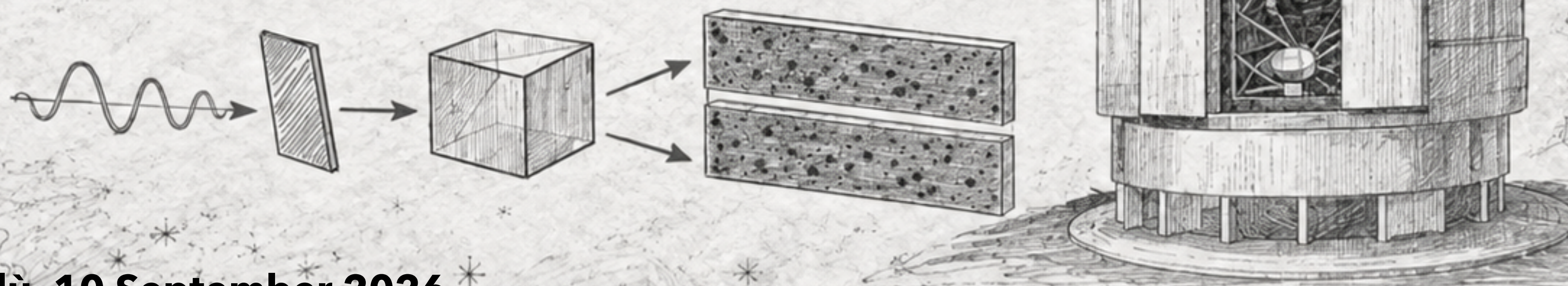
The "Italian Black Holes"



M. Cristina Baglio

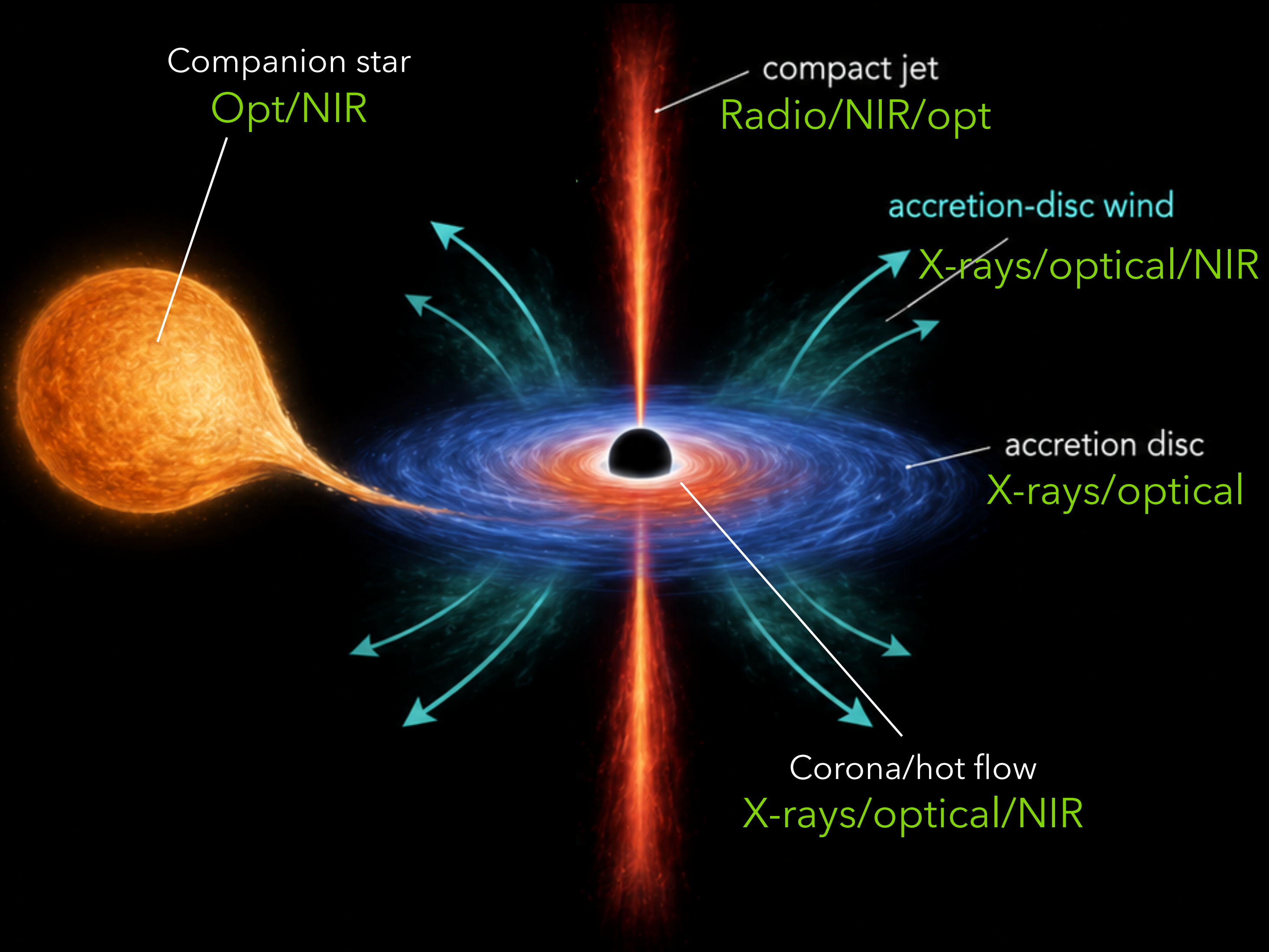
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The many tones of accretion - Cefalù, 10 September 2026

Black Hole Low Mass X-ray binaries

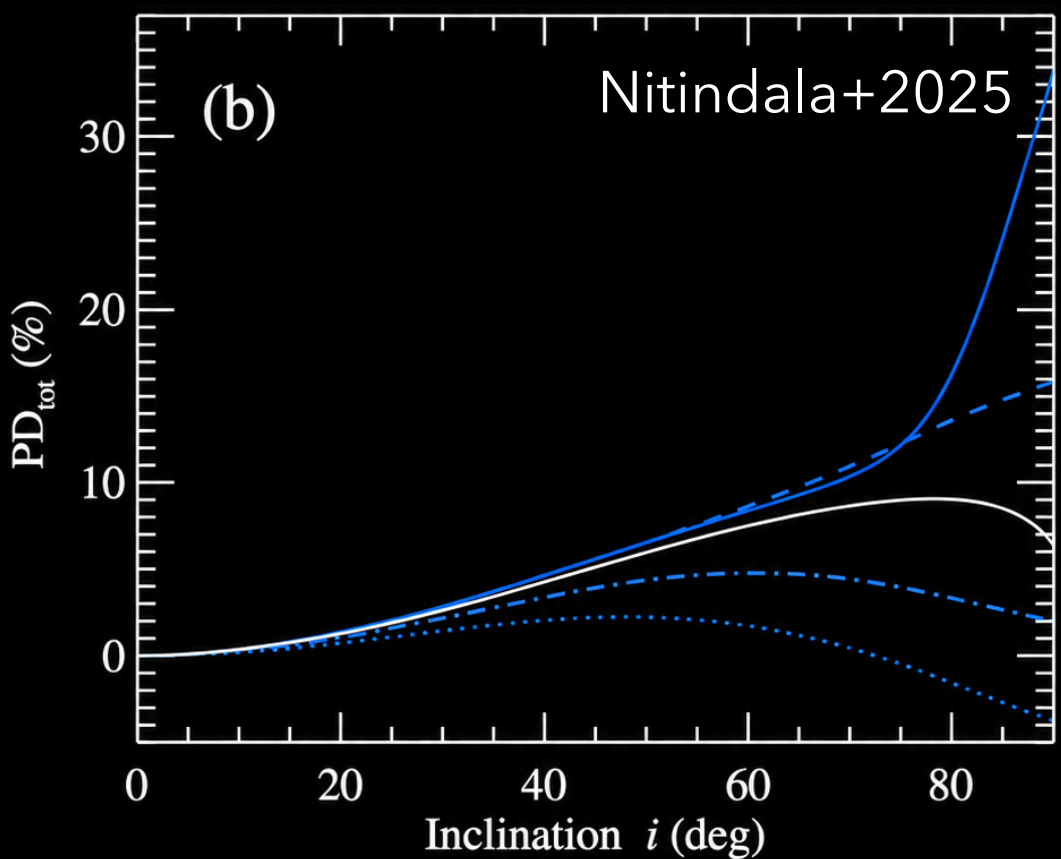
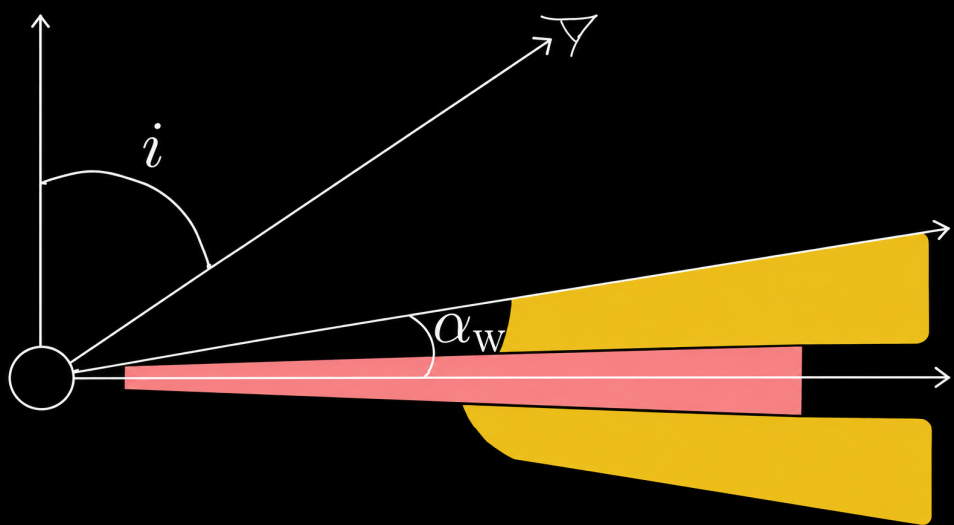


OIR polarization of X-ray binaries

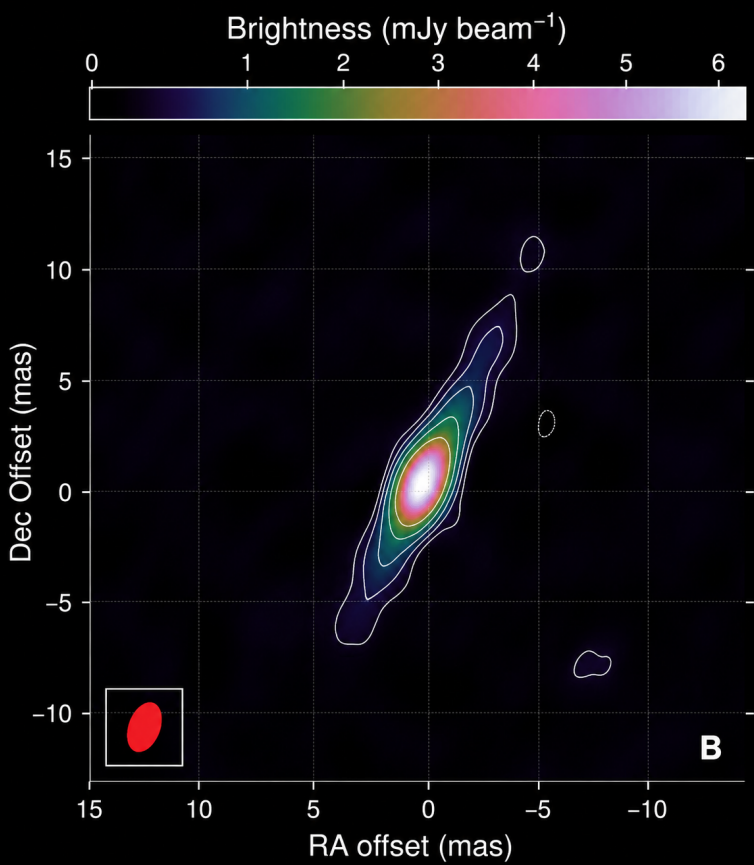
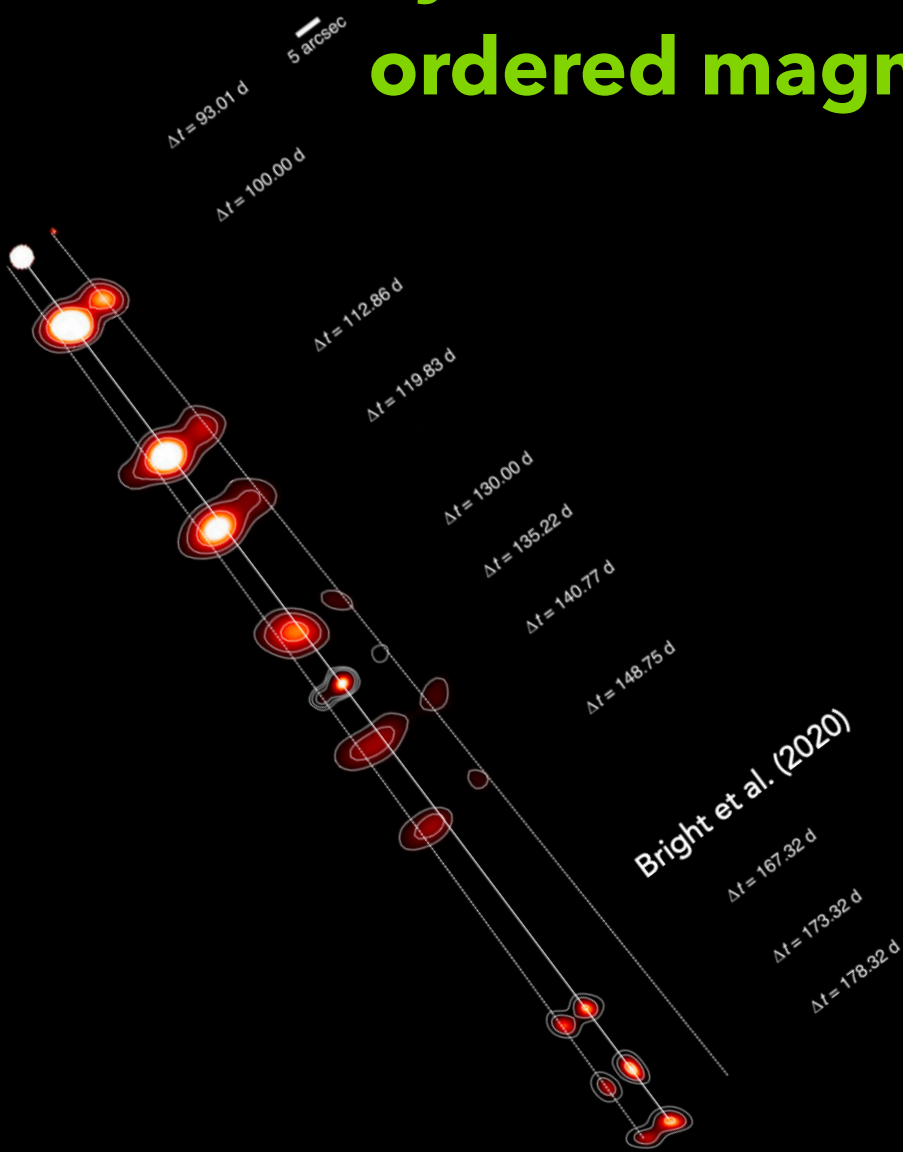
Scattering

By electrons in the accretion disc atmosphere

By electrons in the wind

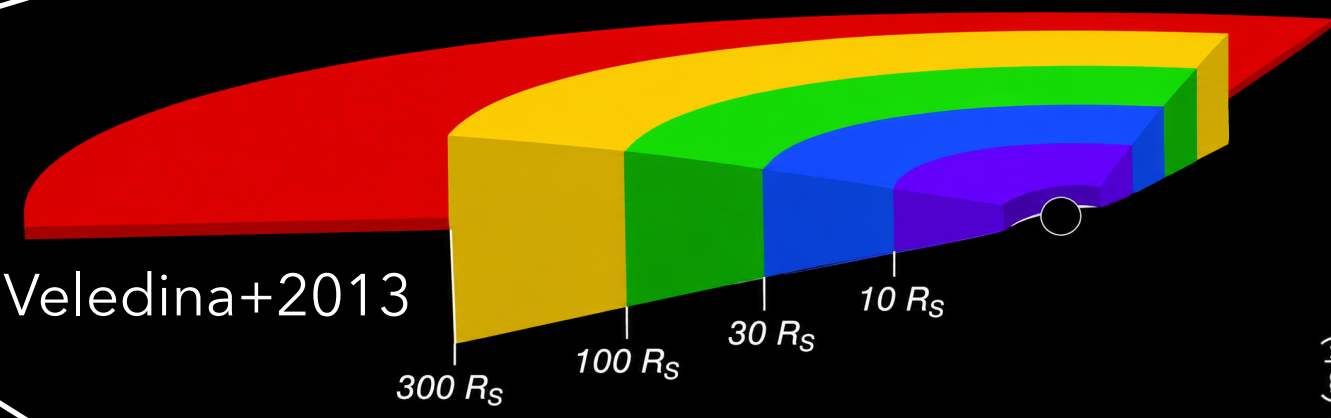


Synchrotron emission in the presence of ordered magnetic fields



Miller-Jones+2021

Hot accretion flow

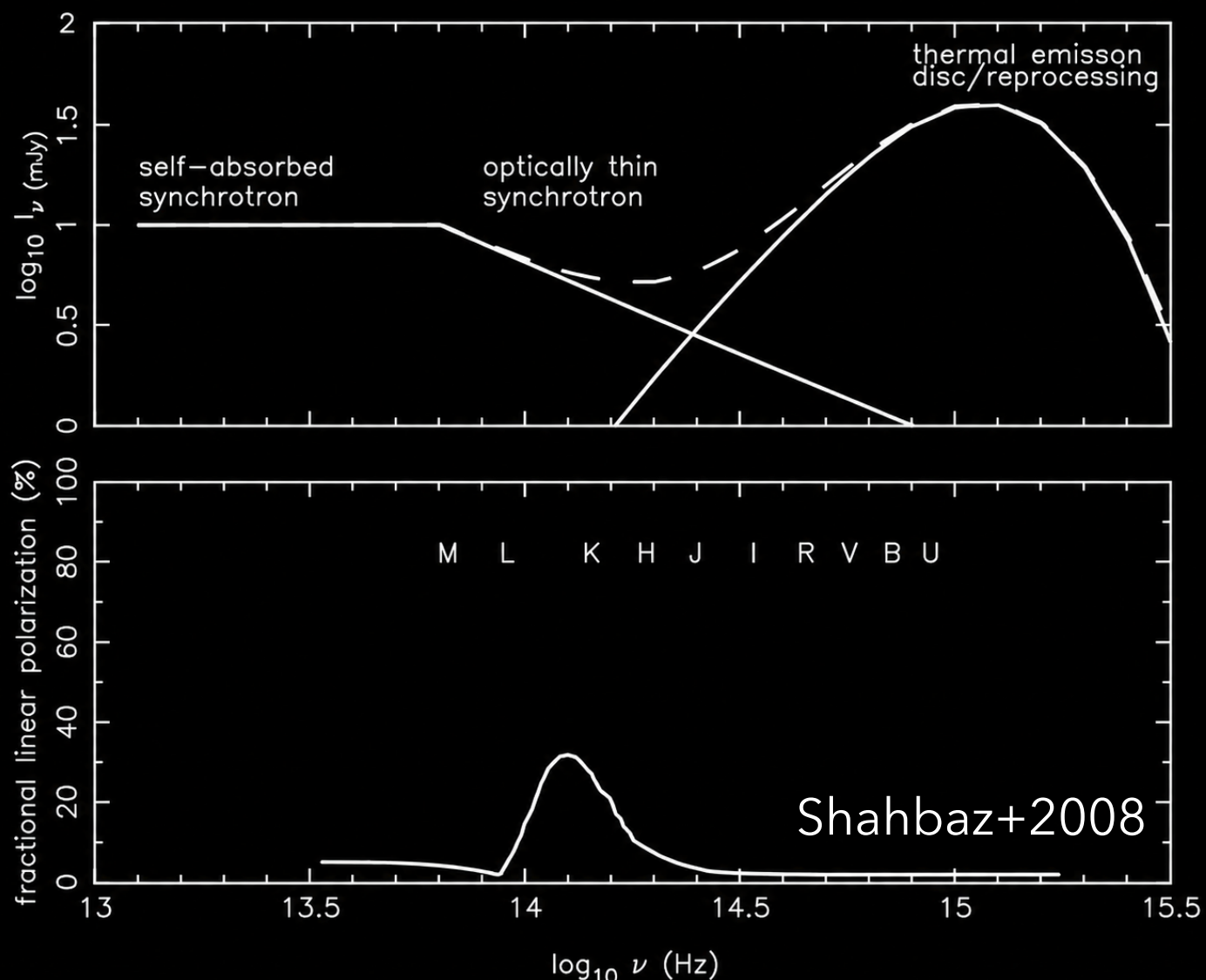


Veledina+2013

Jet

Compact Jet

Discrete ejecta



GX 339-4

Is GX 339-4 a blackhole?

If a blackhole,

Spectral Branches

QPO

LFN

} Neutron-star surface

is not an important element.

If a neutron star,

Ultra softness of the spectrum

cannot be considered as

an important signature of a black hole.

Tomaso Belloni, a conference a long time ago...

GX 339-4

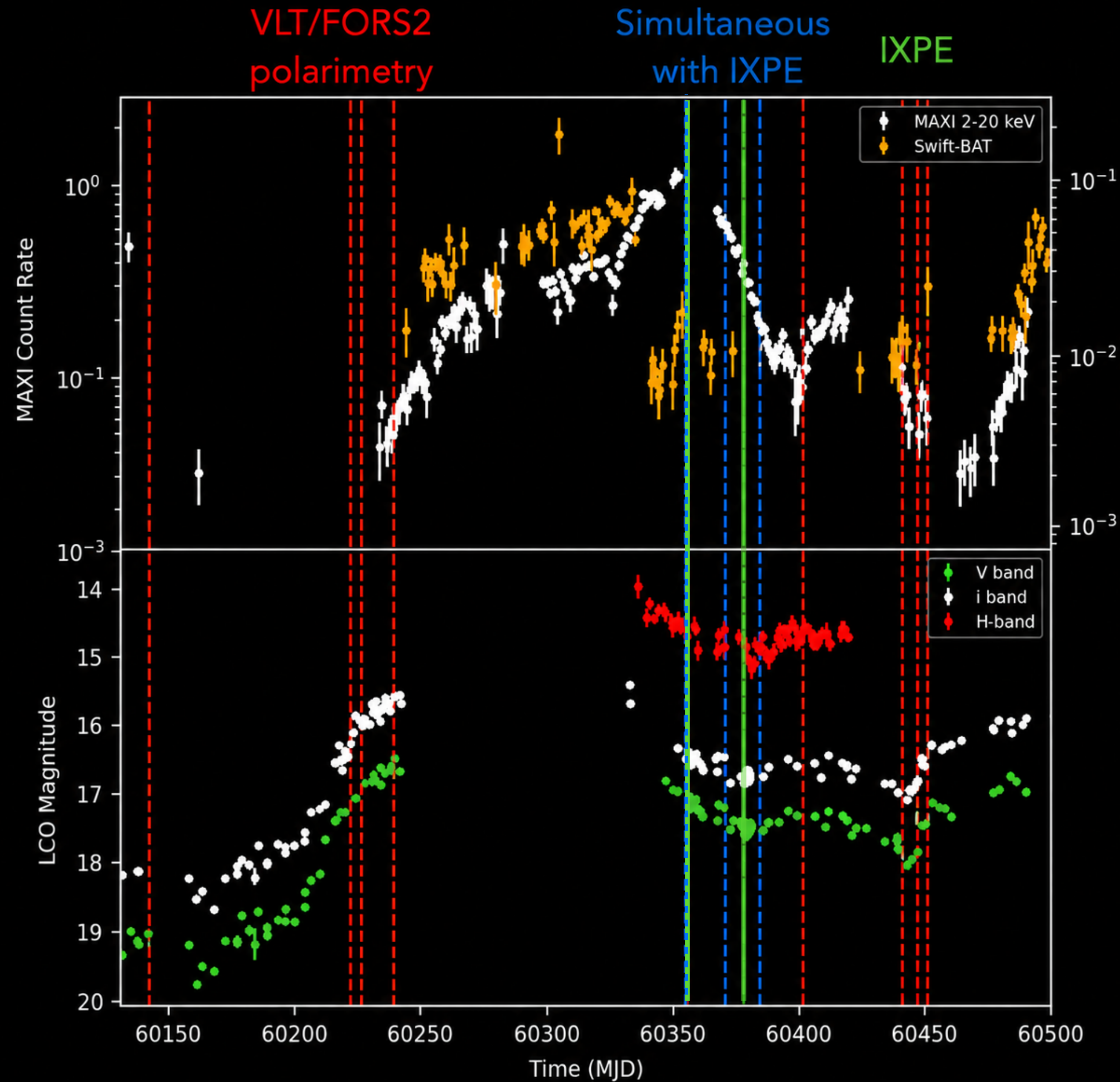
Extensive campaign performed during last outburst

Optical polarimetry during all different states

Simultaneous observations with IXPE!

Mastroserio, De Marco, Baglio et al. 2025

IXPE+VLT campaign performed during soft-intermediate and soft state



GX 339-4

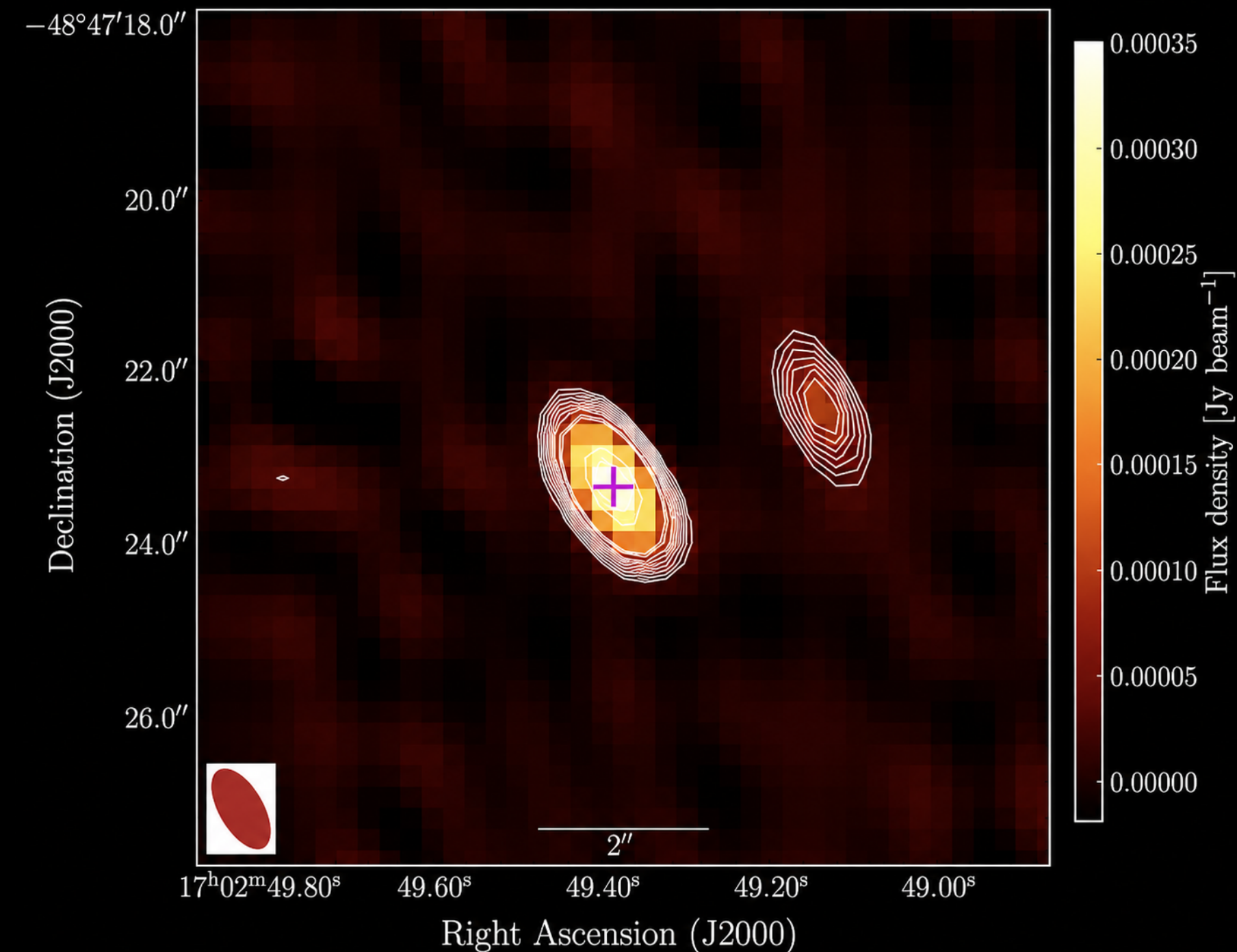
Extensive campaign performed during last outburst

Optical polarimetry during all different states

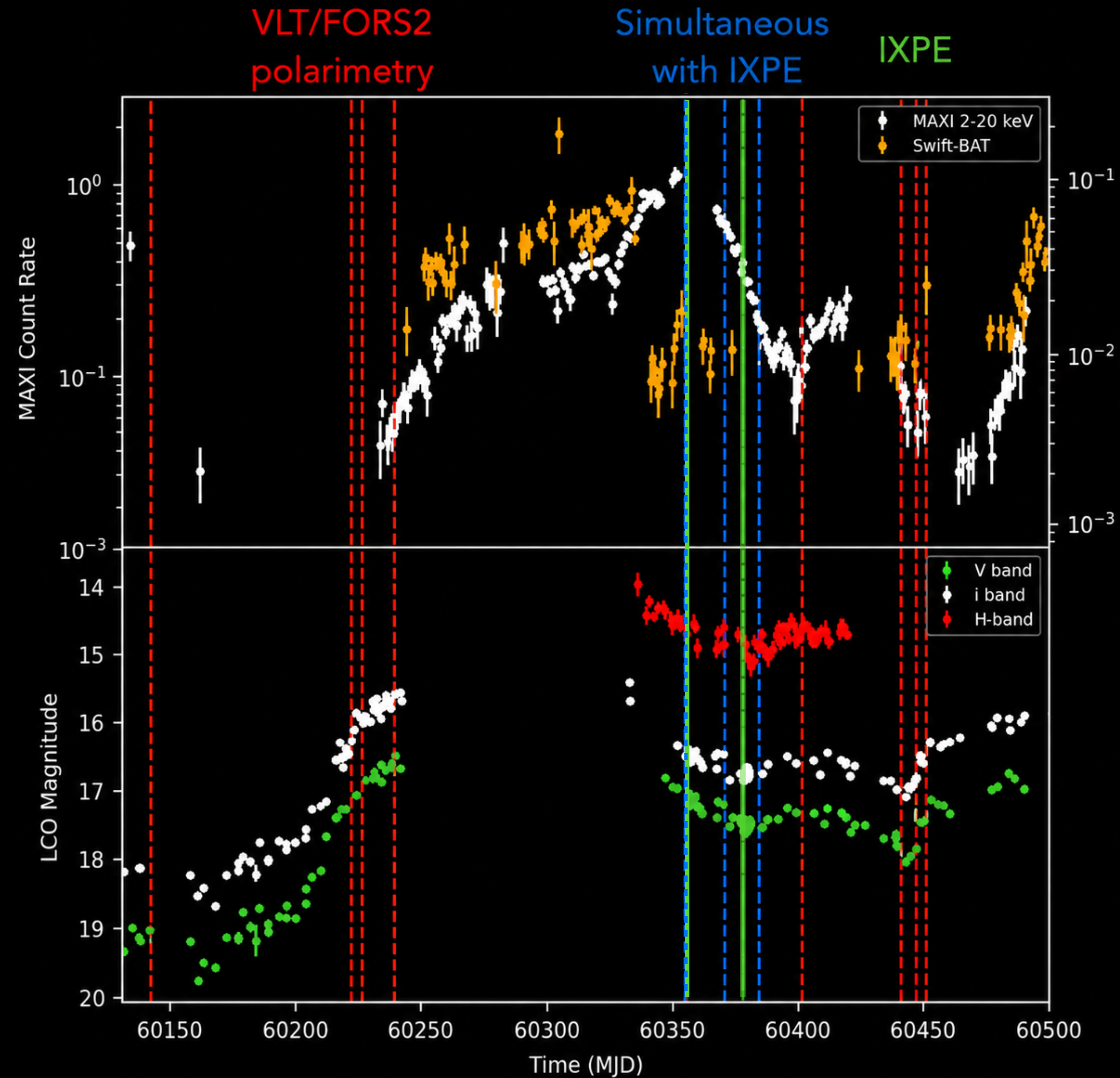
Simultaneous observations with IXPE!

Mastroserio, De Marco, Baglio et al. 2025

IXPE+VLT campaign performed during soft-intermediate and soft state

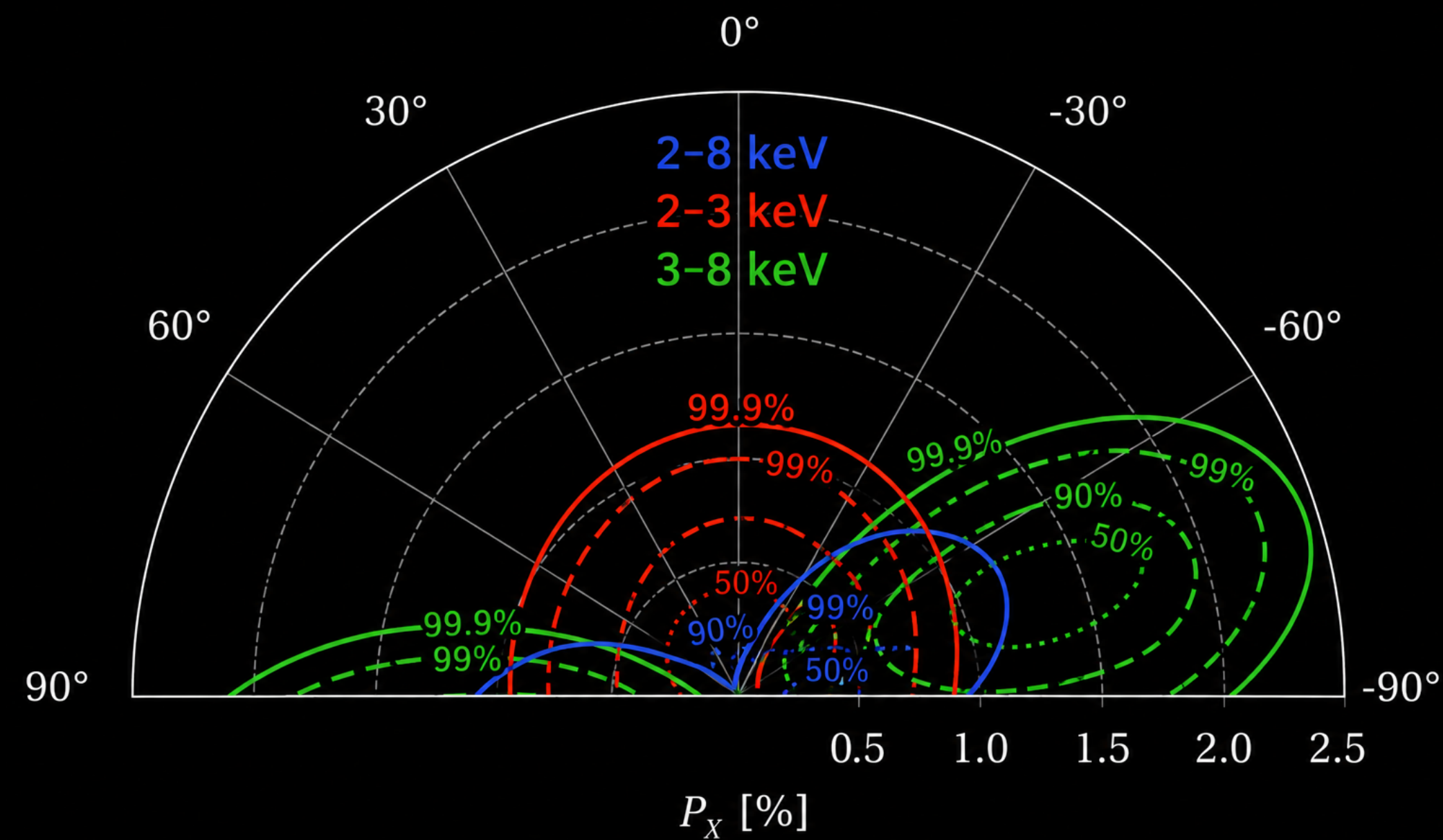


Simultaneous radio detection of ejections: we can estimate the direction of the jet!



GX 339-4

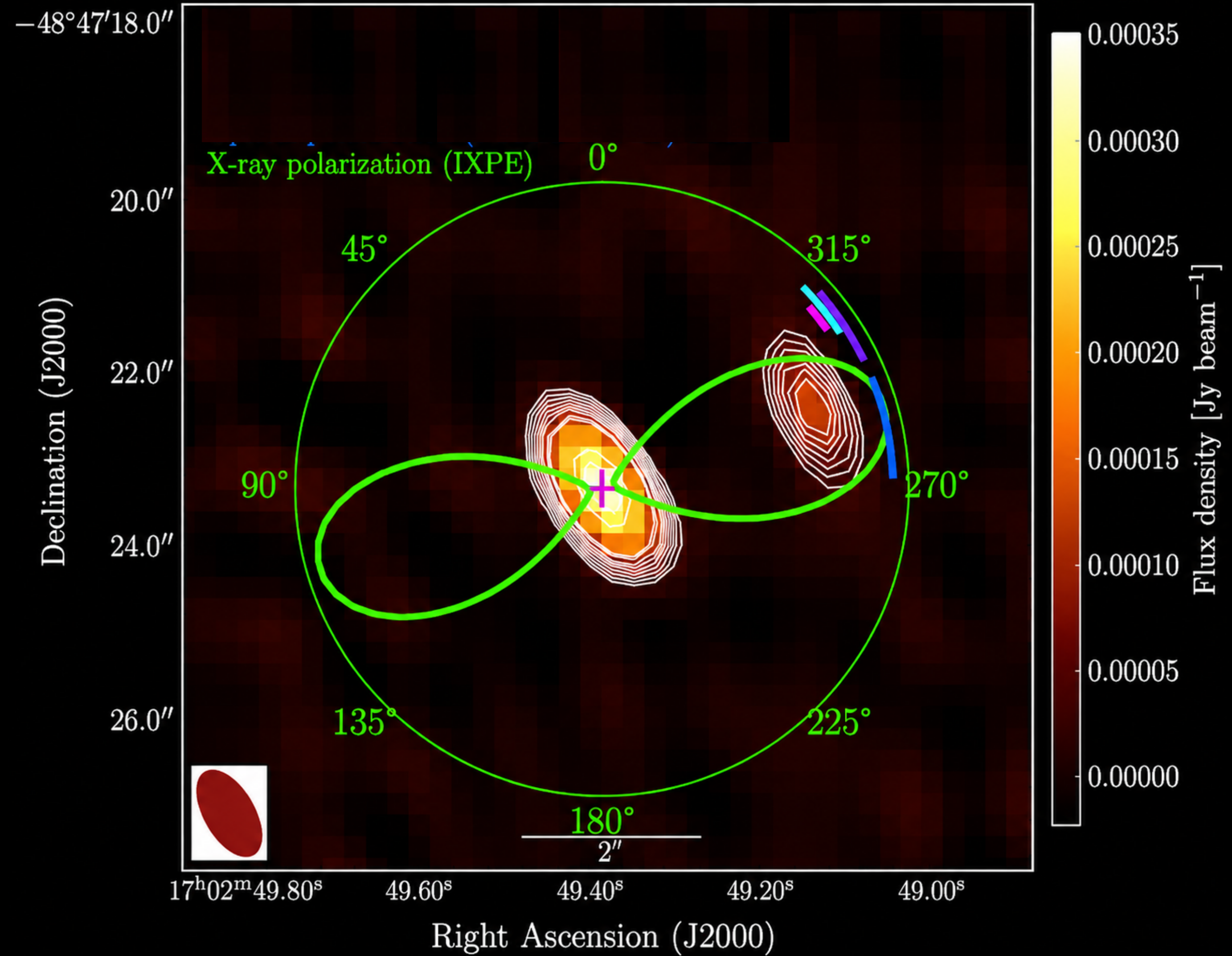
Epoch 1 IXPE (soft-intermediate)



Significant polarization in 3-8 keV band: $P_x = 1.3 \pm 0.3$ %

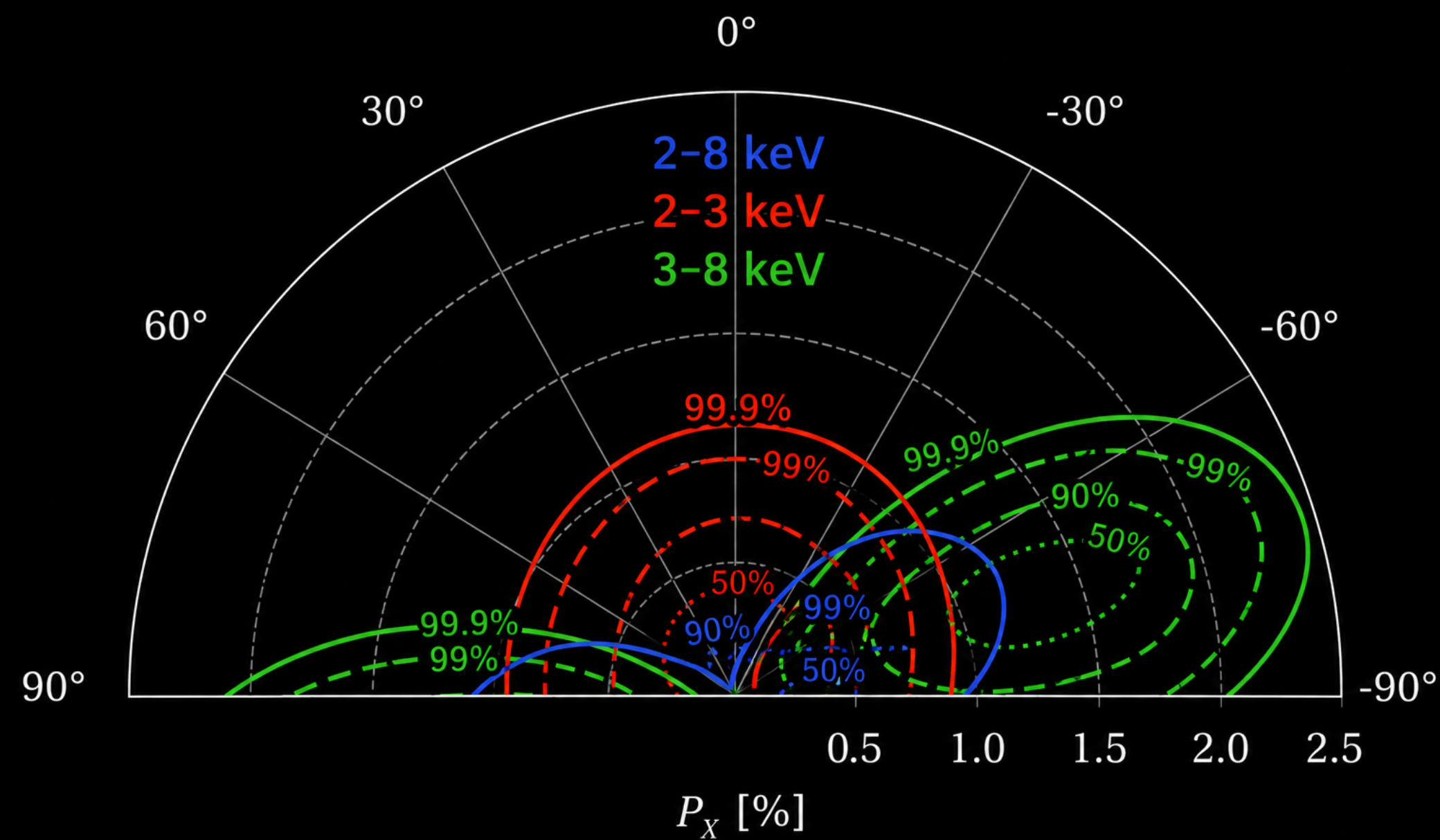
Pol angle: $-74^\circ \pm 7^\circ$

Epoch 2 IXPE: polarization upper limit ($< 1.2\%$)



GX 339-4

Epoch 1 IXPE (soft-intermediate)

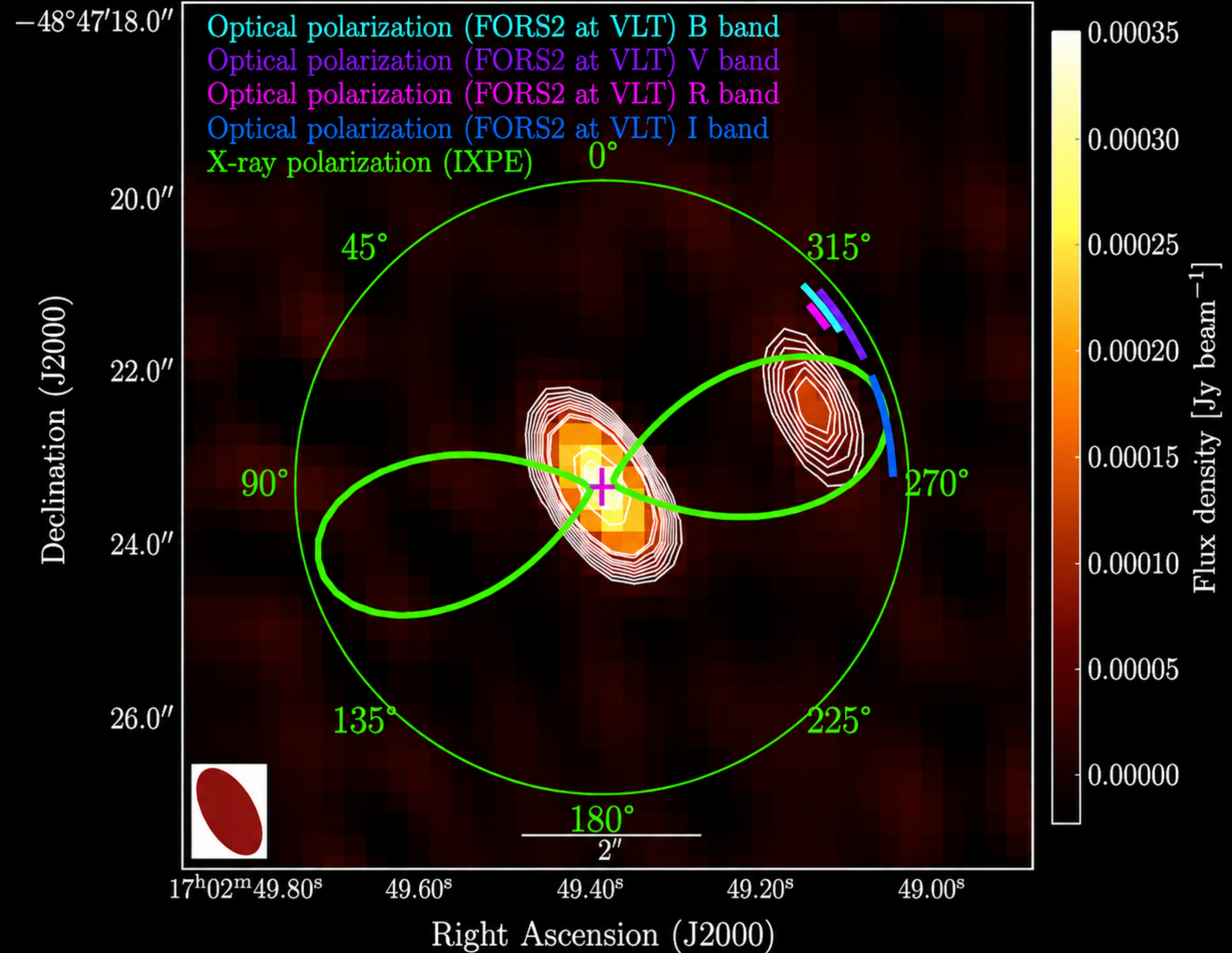


Significant polarization in 3-8 keV band: $P_x = 1.3 \pm 0.3$ %

Pol angle: $-74^\circ \pm 7^\circ$

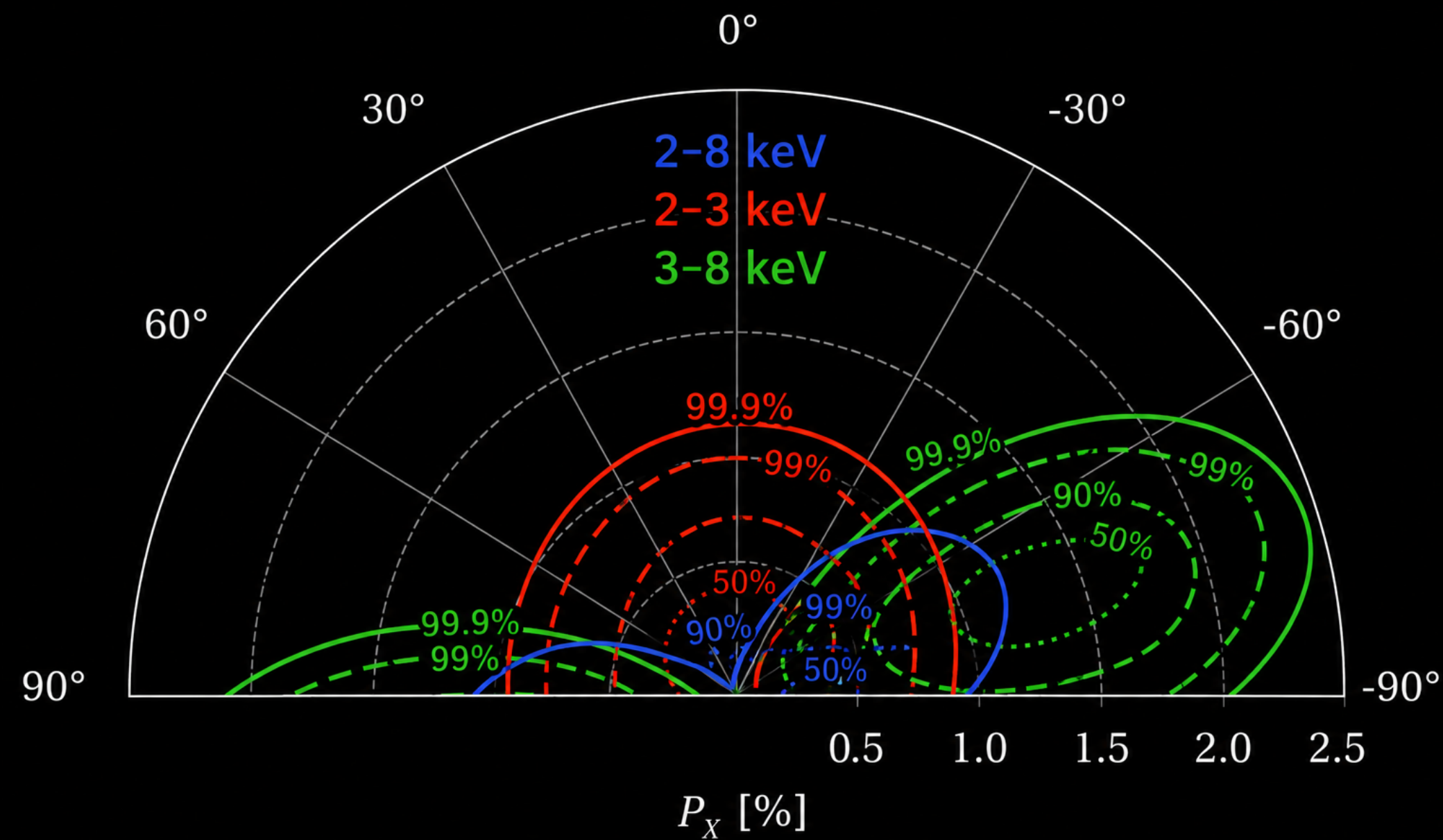
Epoch 2 IXPE: polarization upper limit ($< 1.2\%$)

Optical polarization 0.3-1%, aligned with X-ray pol.



GX 339-4

Epoch 1 IXPE (soft-intermediate)

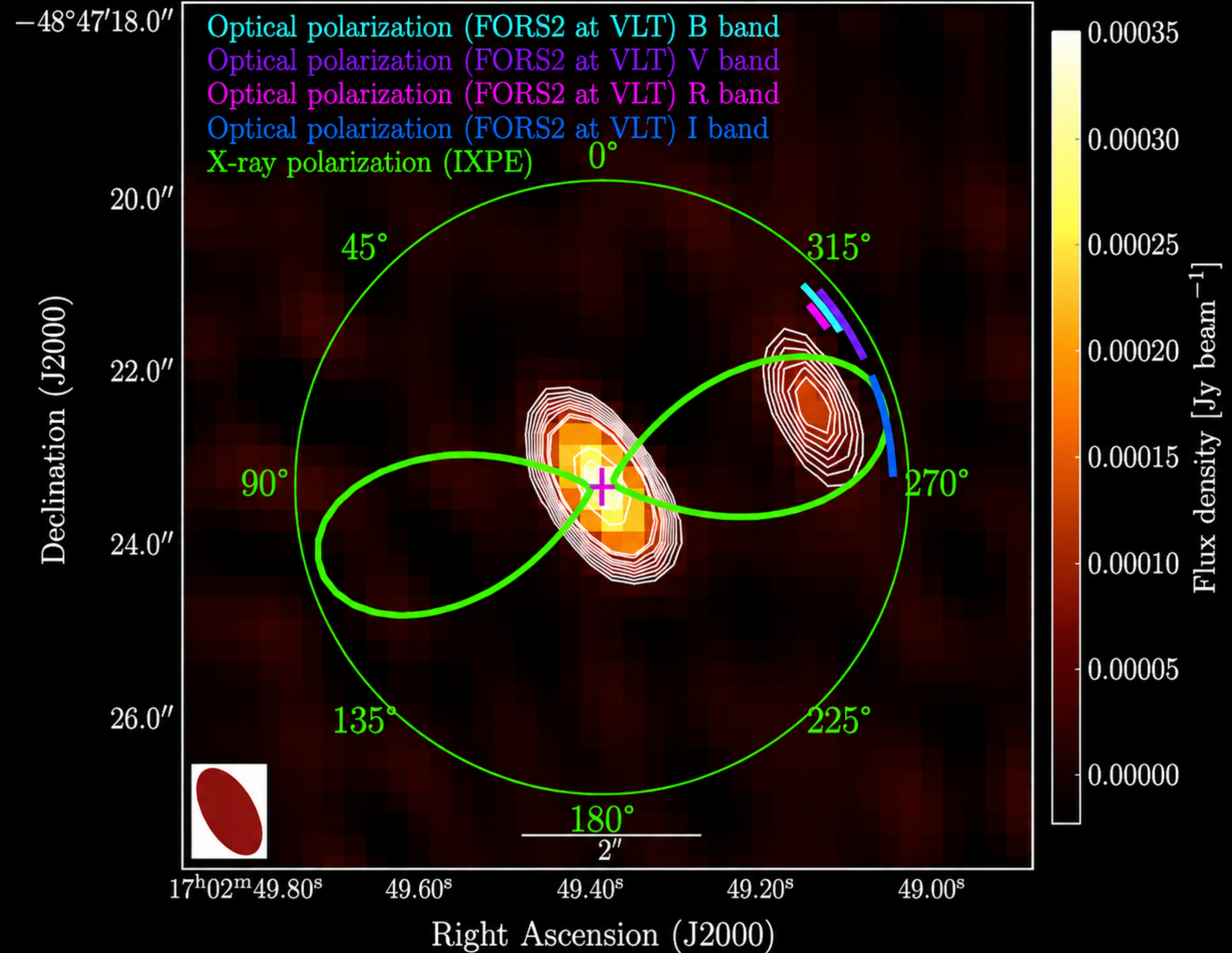


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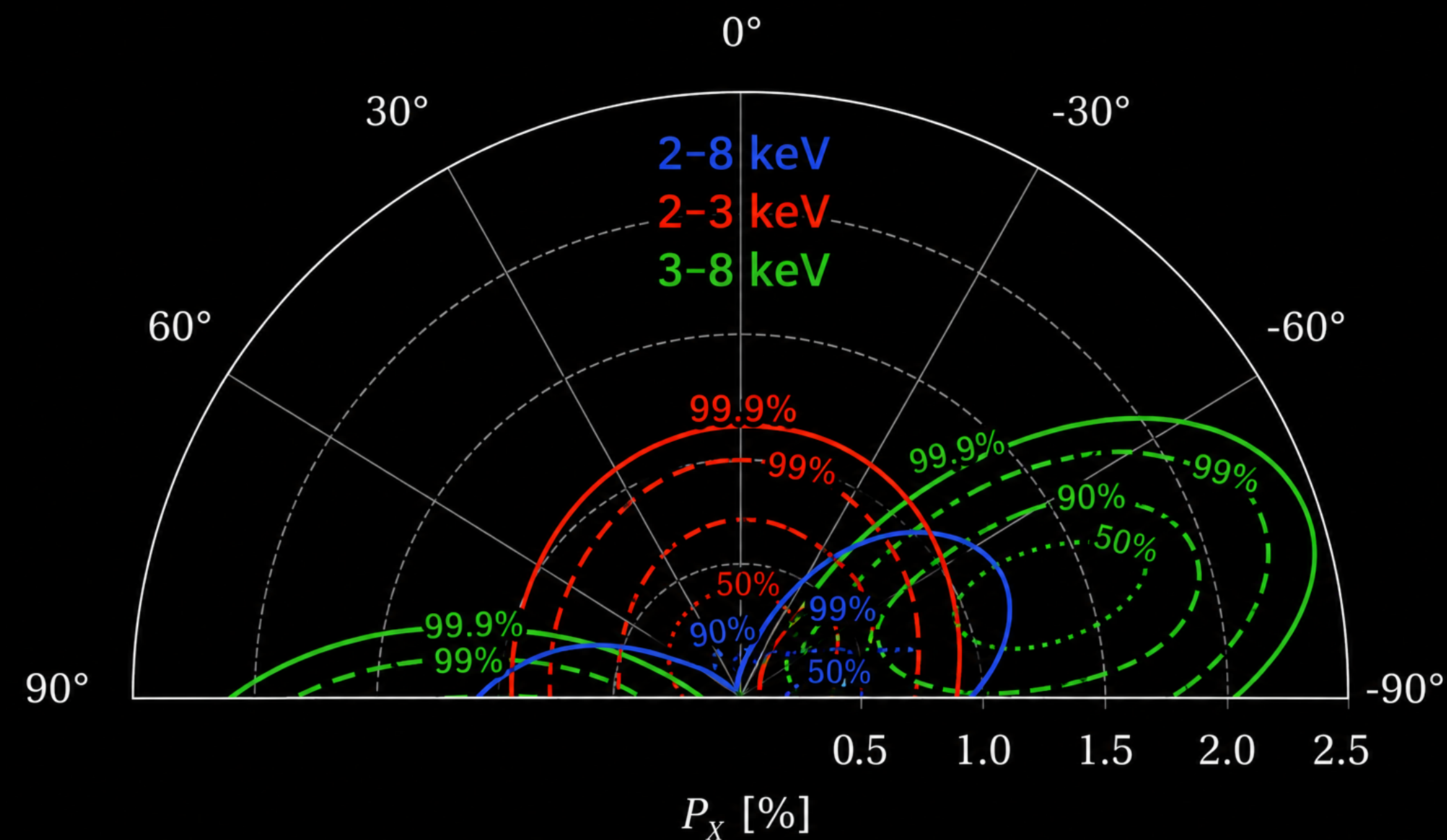


The corona is horizontally extended on the plane of the accretion disk and the optical is produced from the outer regions of the disk.

Optical polarization likely from scattering in the disc atmosphere.

GX 339-4

Epoch 1 IXPE (soft-intermediate)



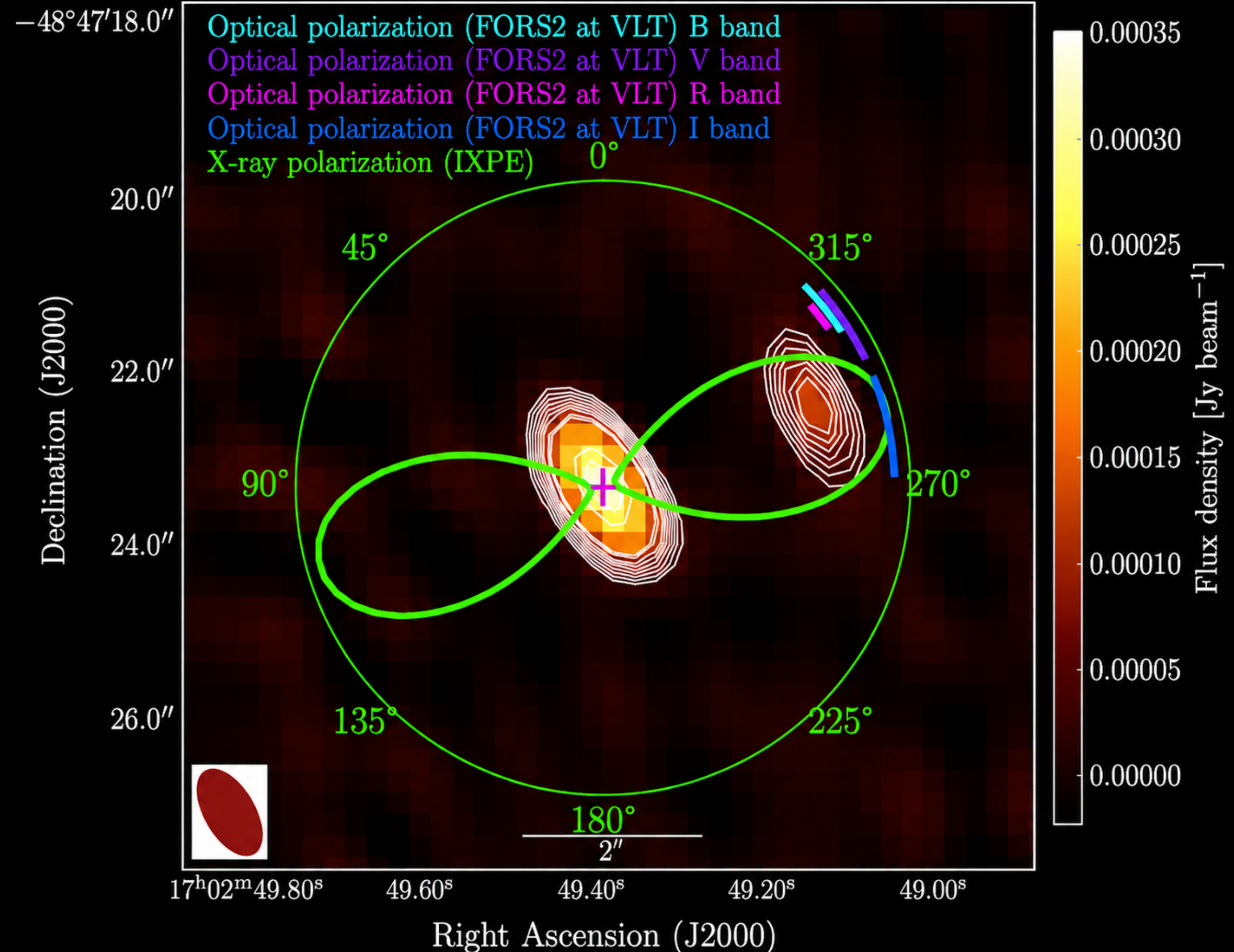
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Pol angle: $-74^\circ \pm 7^\circ$

Epoch 2 IXPE: polarization upper limit ($< 1.2\%$)

Optical polarization 0.3-1%, aligned with X-ray pol.

MORE TO COME in 2027(ish): the whole opt pol campaign!

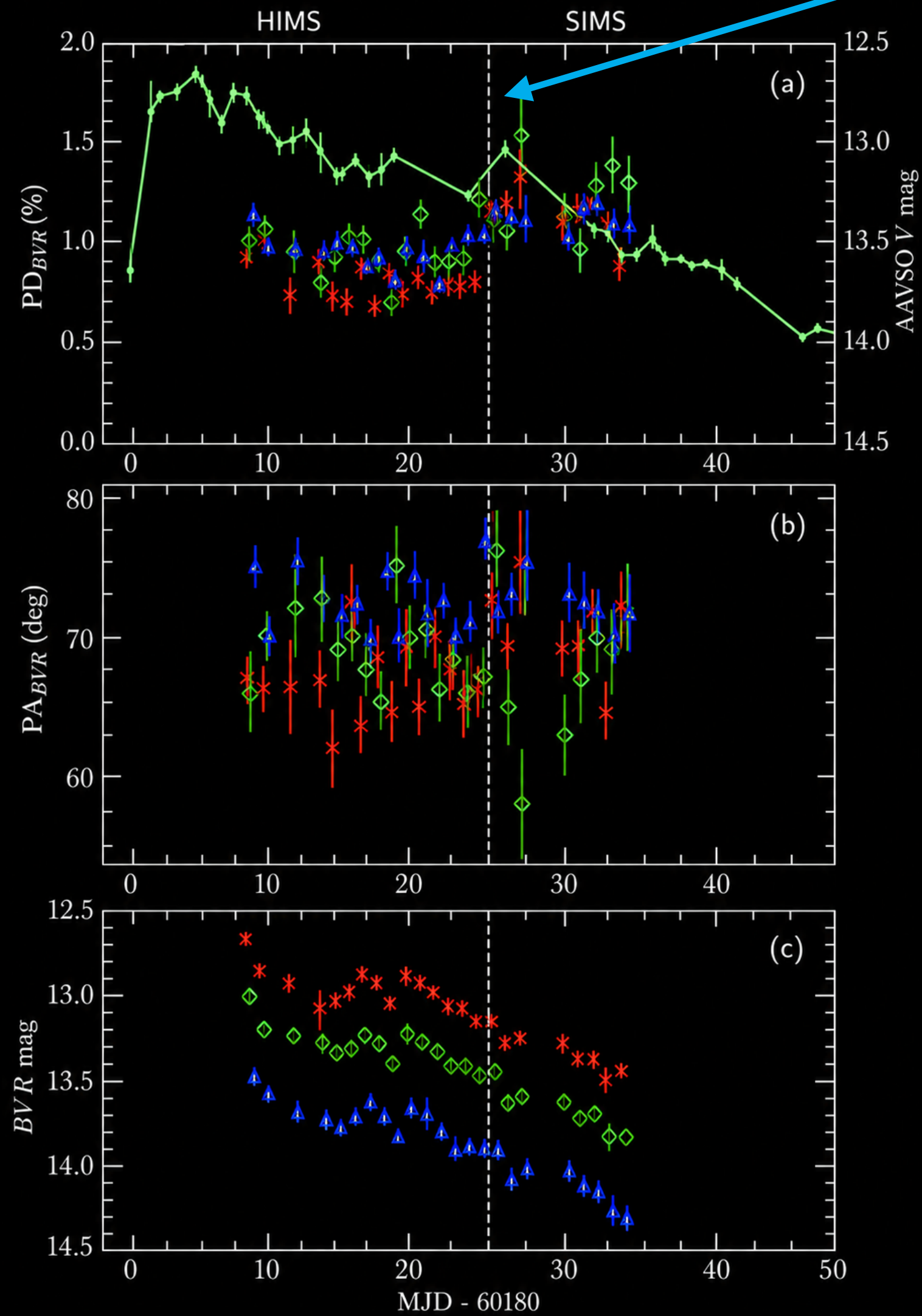


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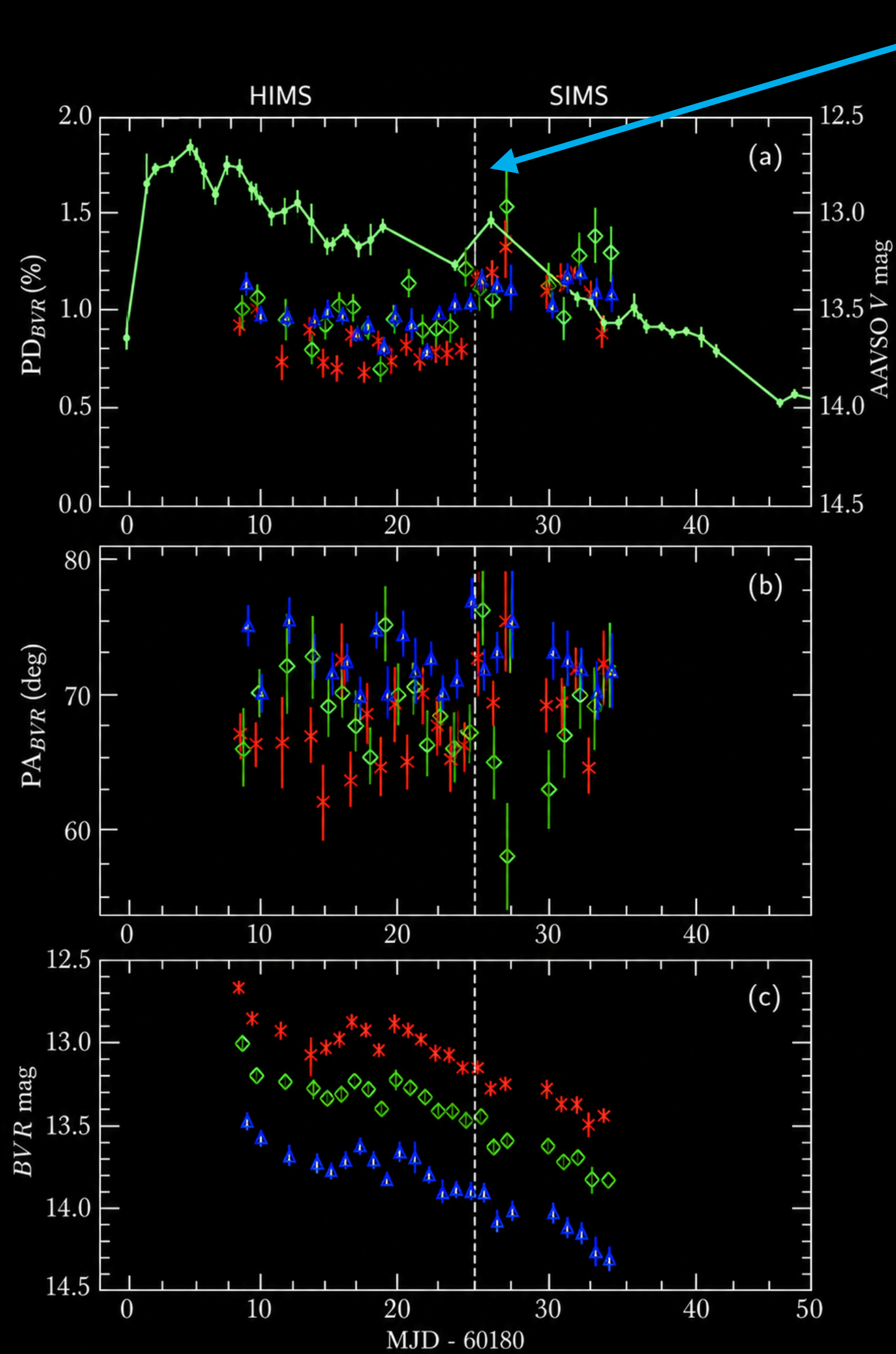
Swift J1727.8–1613

Jet ejections



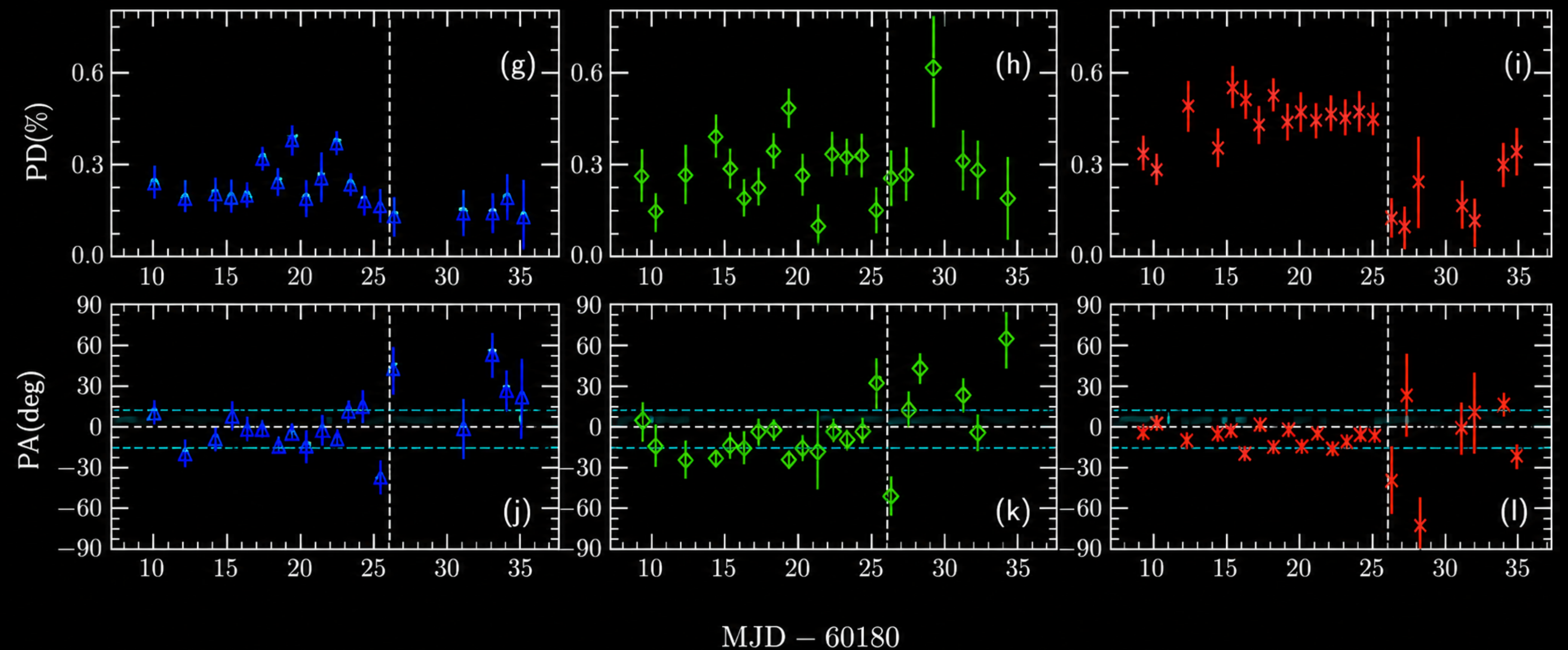
Observational campaign with DiPOL2 during the 2023-2024 outburst of Swift J1727

Swift J1727.8–1613



Observational campaign with DiPOL2 during the 2023-2024 outburst of Swift J1727

~1% observed pol; 0.3% intrinsic polarization measured after ISM correction.



After ISM correction, a drop of PD is observed at the transition.

Opt polarization may come from scattering in the wind. The angle does not change in HIMS and SIMS.

Swift J1727.8–1613

X-ray polarization (measured by IXPE) has PA $\sim 2^\circ$,
aligned with the jet axis.

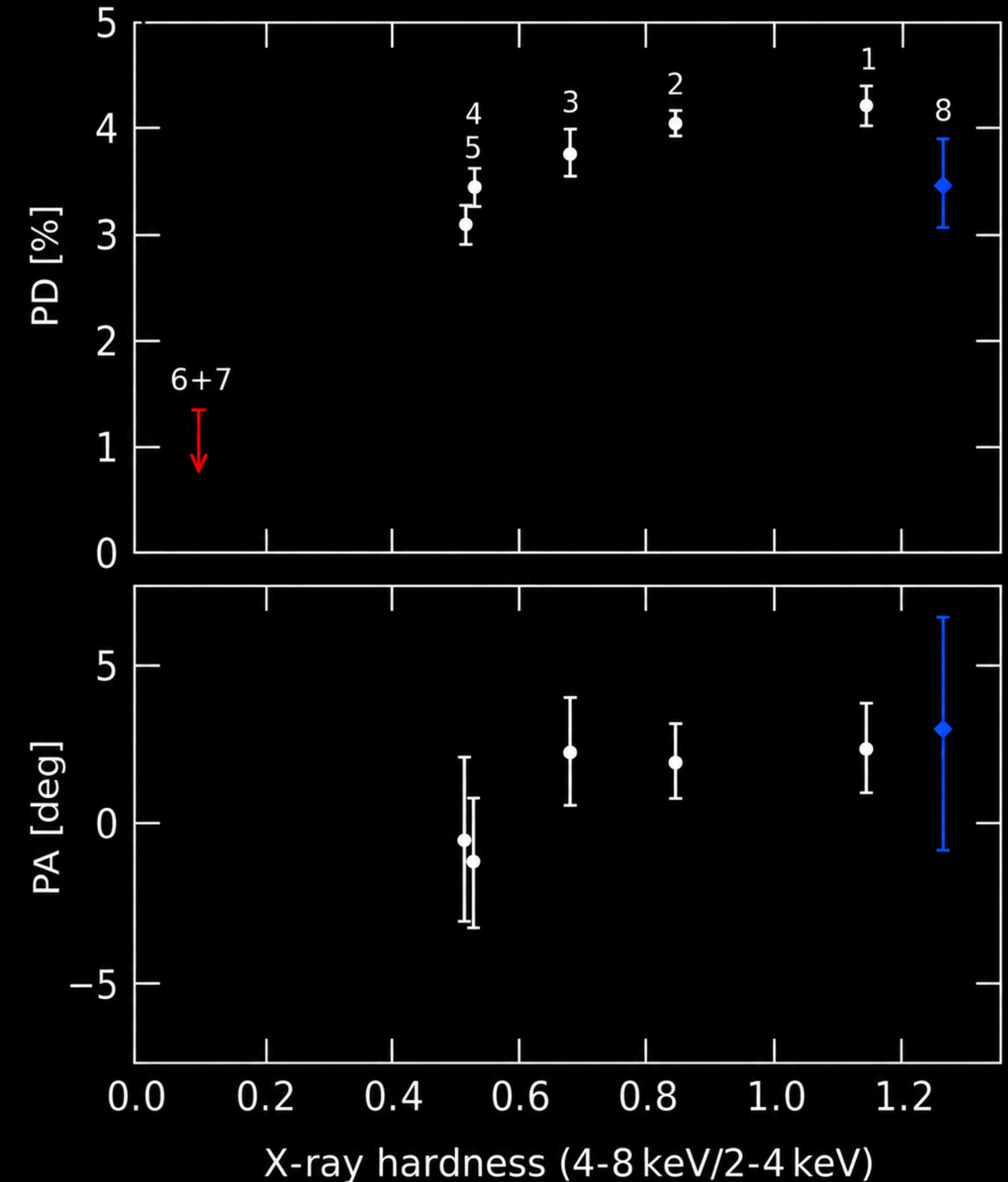
Interpreted as Compton scatterings in a hot corona that is flattened,
lying in the plane of the disk.

Nitindala 2026 measures an optical PA of $\sim -15^\circ$: mismatch with IXPE PA.

Winds : axis of symmetry of the outer parts of the disk, which may align with
the orbital axis.

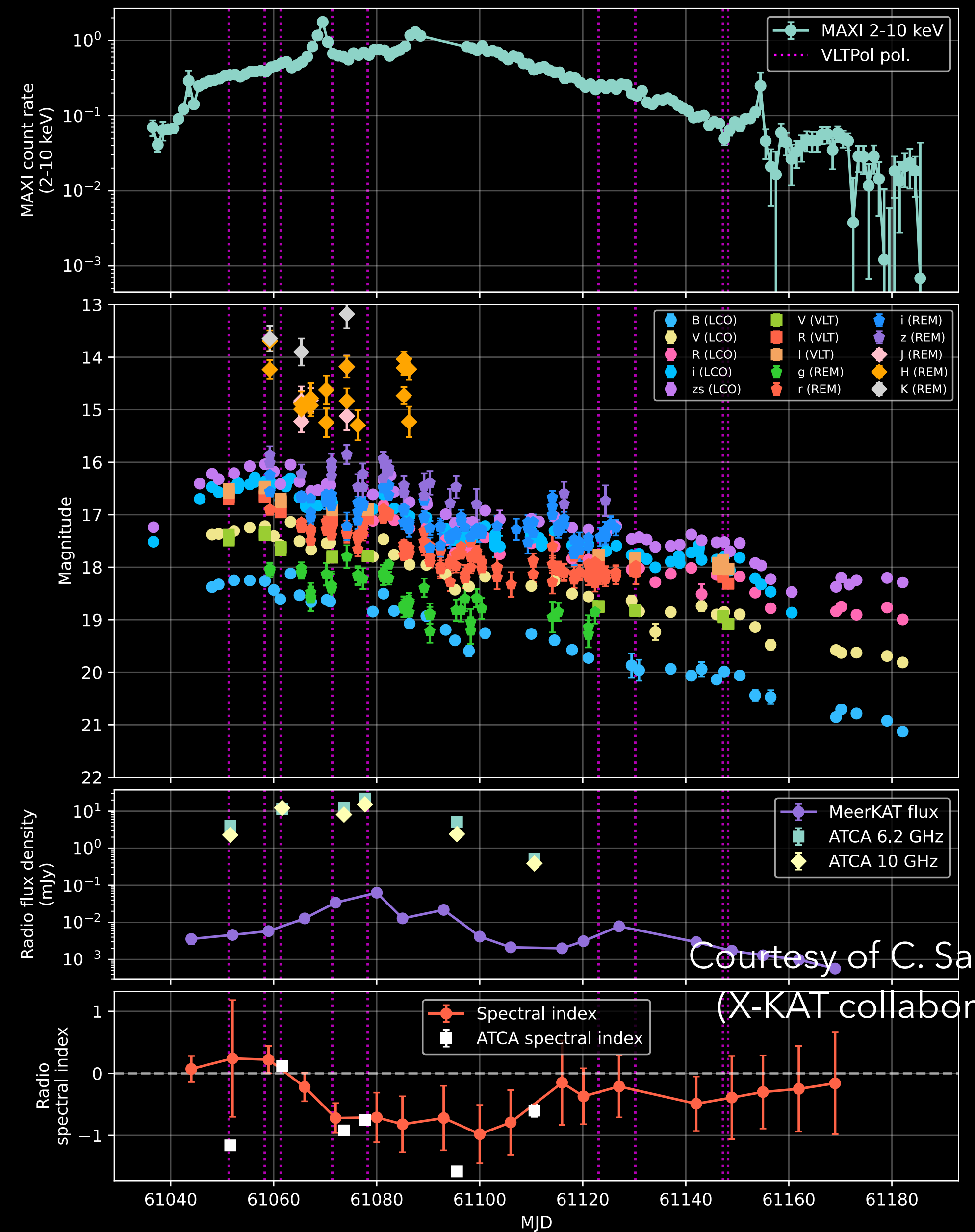
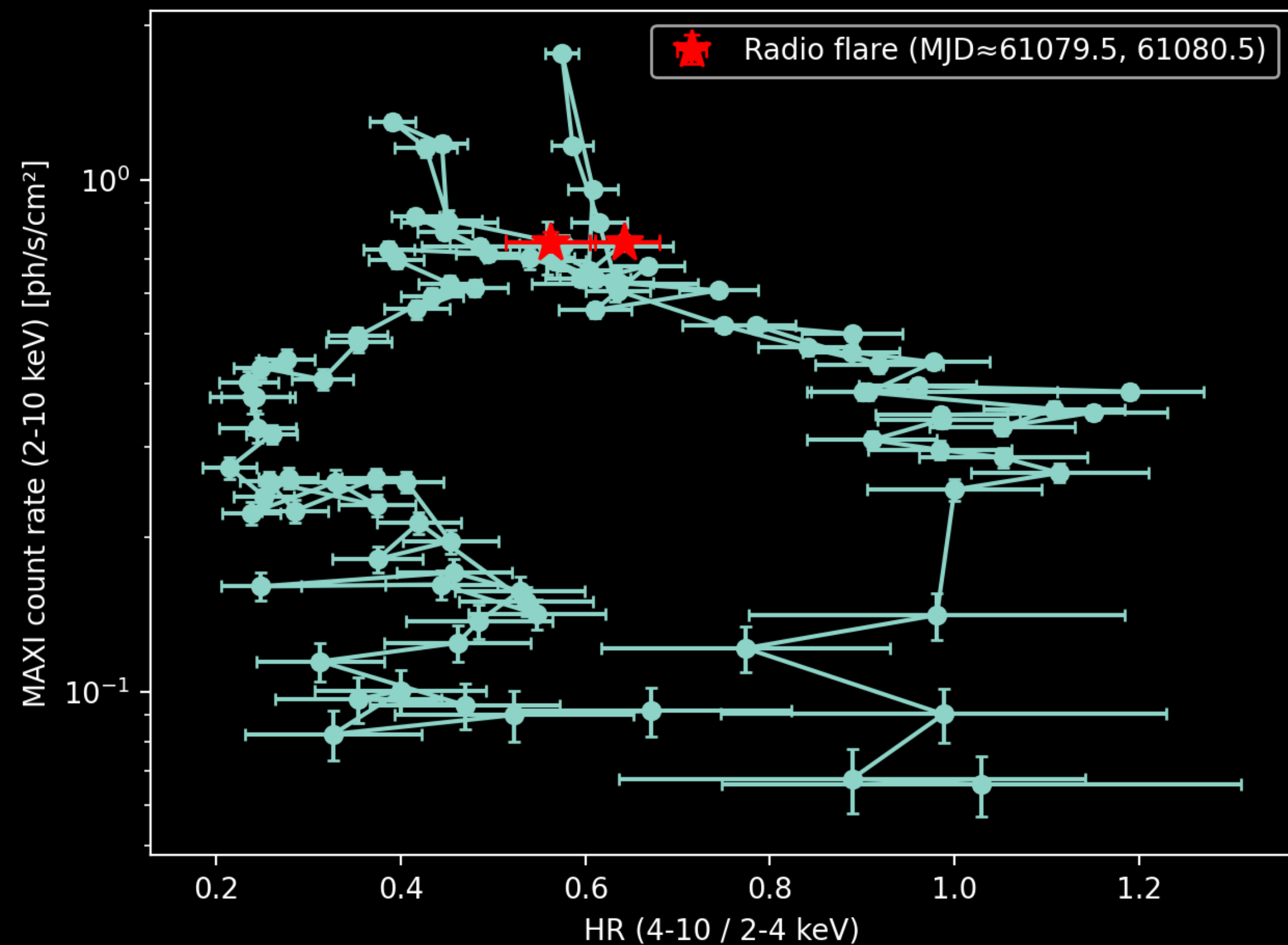
X-ray polarization is aligned with the jet axis (i.e. the axis of the BH spin).

The mismatch between the optical and X-ray PAs can then be interpreted as
the signature of misalignment between the BH spin and orbital axes in Swift
J1727.8–1613, similar to MAXI J1820+070 (Poutanen et al. 2022).



GS 1354-645

Outburst started in January 2026

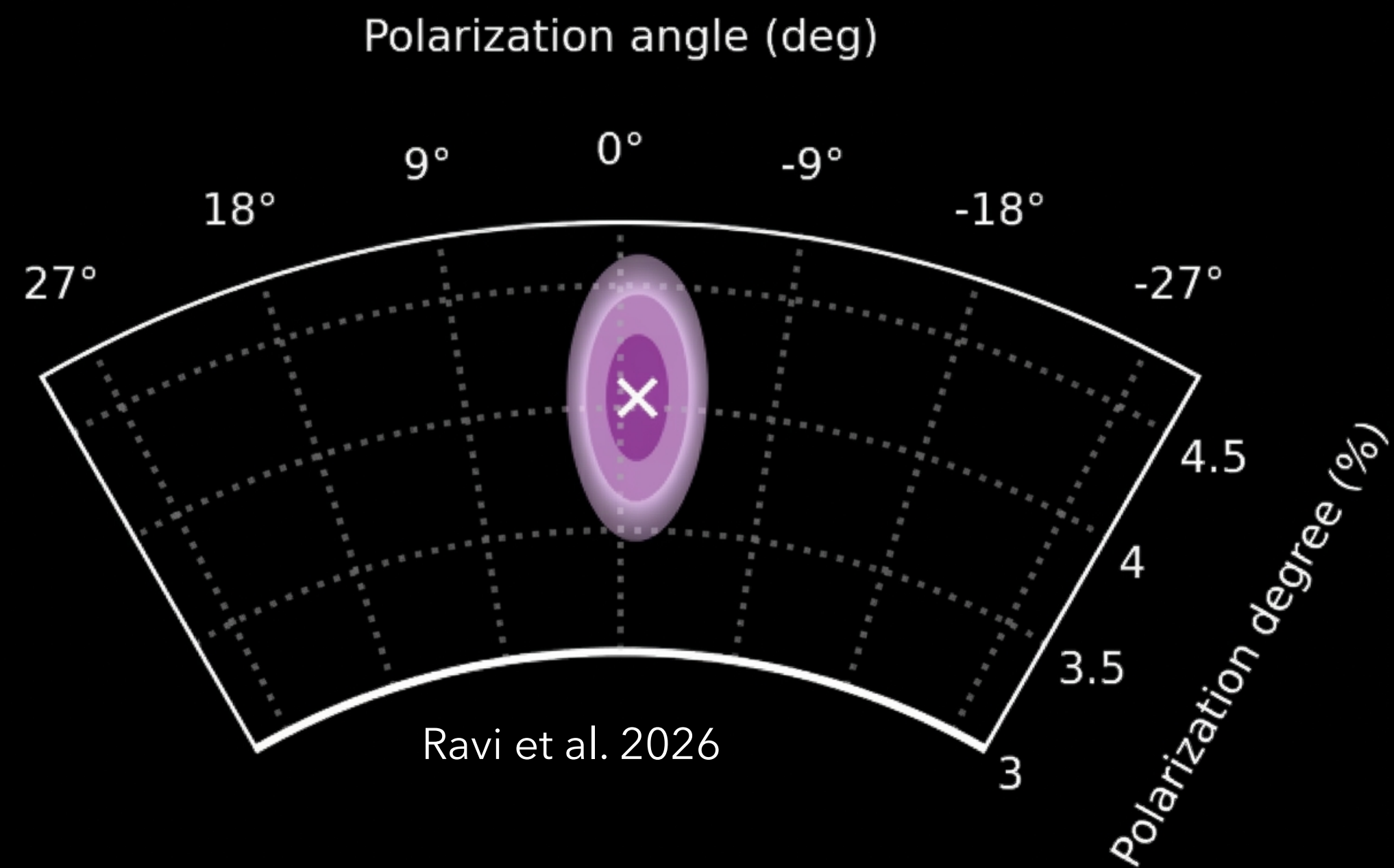


Courtesy of C. Salvaggio
(X-KAT collaboration)

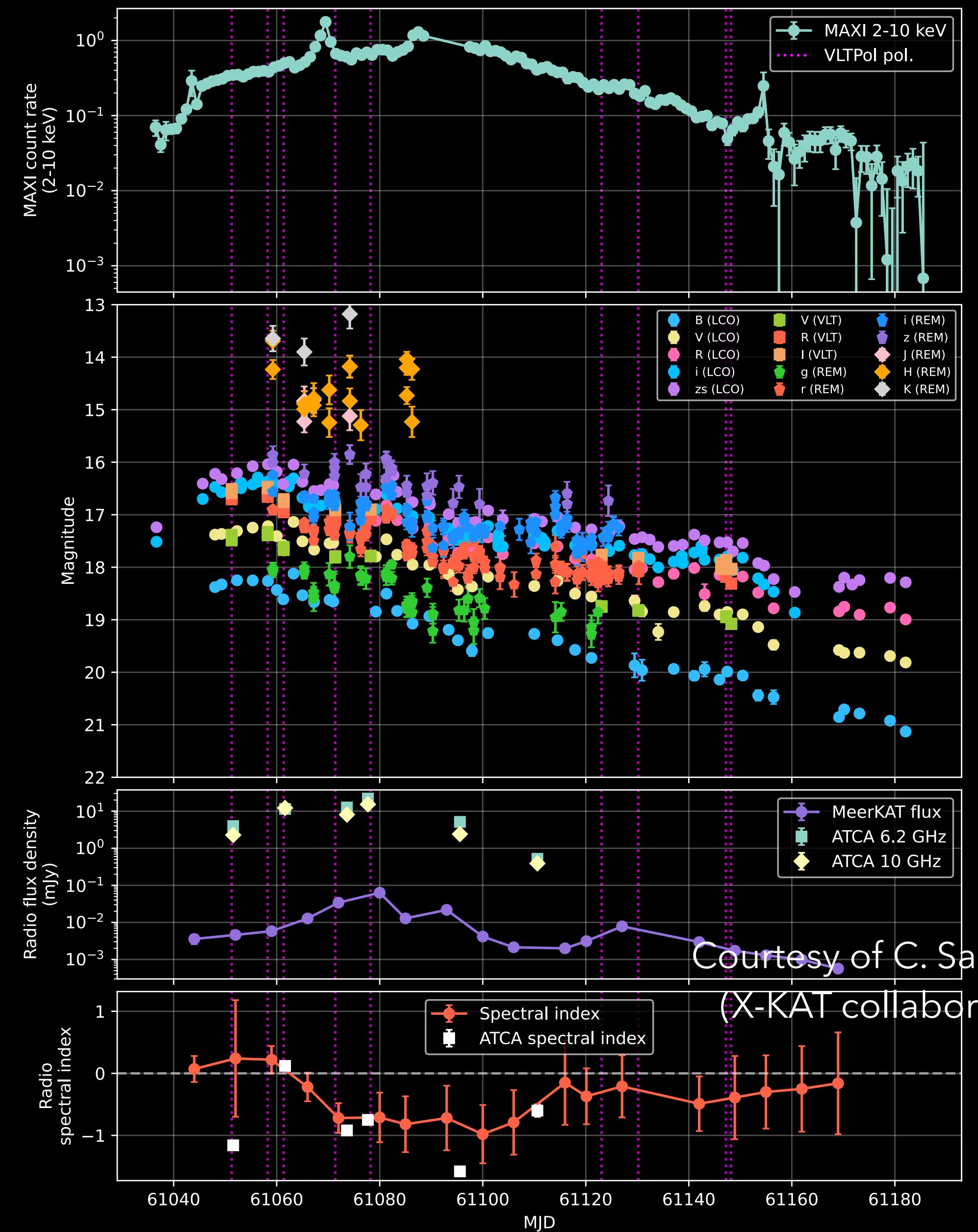
Baglio, Mastroserio et al. in prep

GS 1354-645

IXPE observed on Feb 7-9 (MJD 61078-61080)



X-ray pol consistent with Compton scattering in the corona.



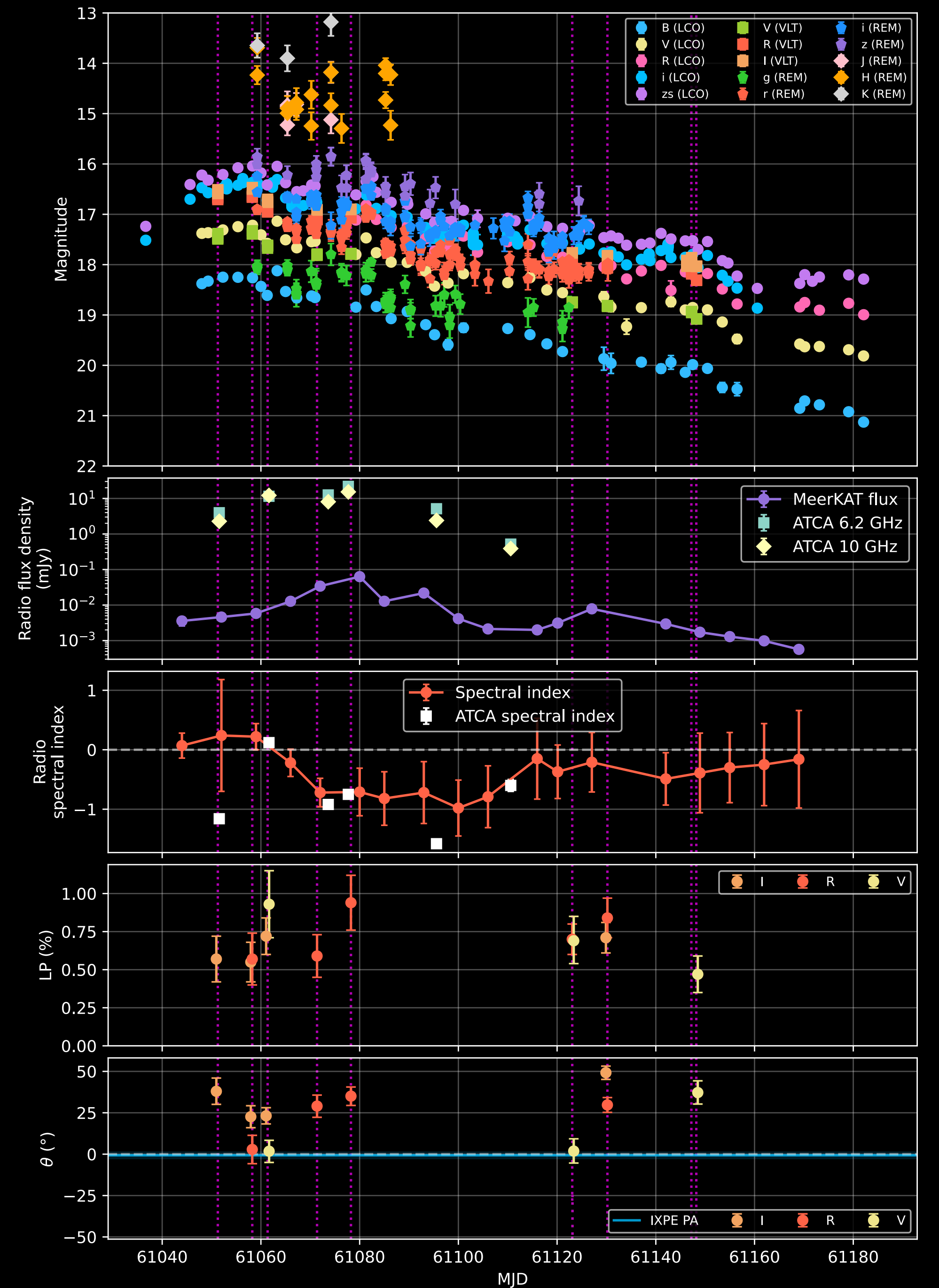
Courtesy of C. Salvaggio
(X-KAT collaboration)

Baglio, Mastroserio et al. in prep

GS 1354-645

Simultaneously with IXPE, optical polarization with VLT (V, R, I filters).

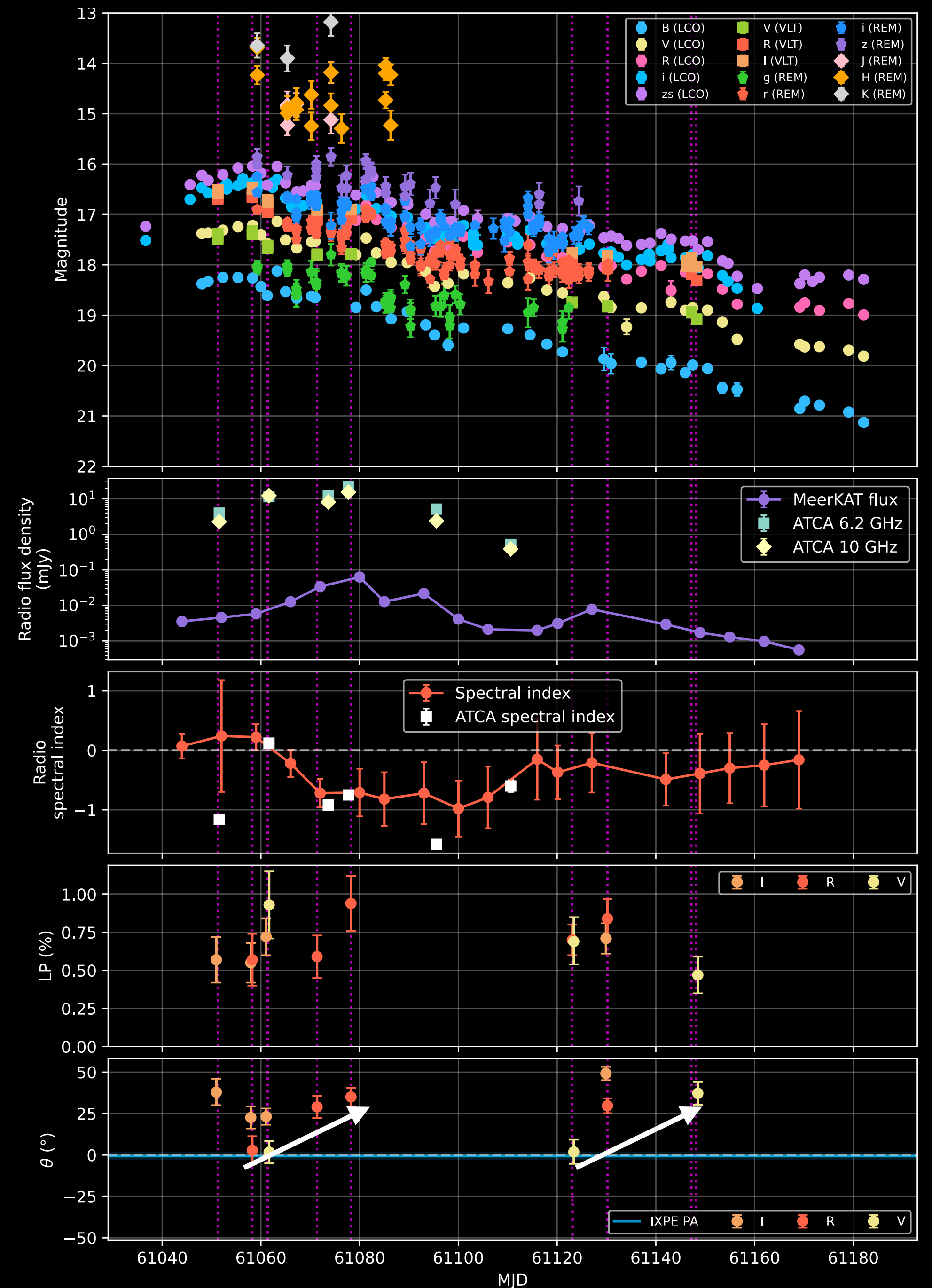
Optical polarization angle rotates at the time of the radio ejection: changes in the origin of the polarization?



GS 1354-645

Simultaneously with IXPE, optical polarization with VLT (V, R, I filters).

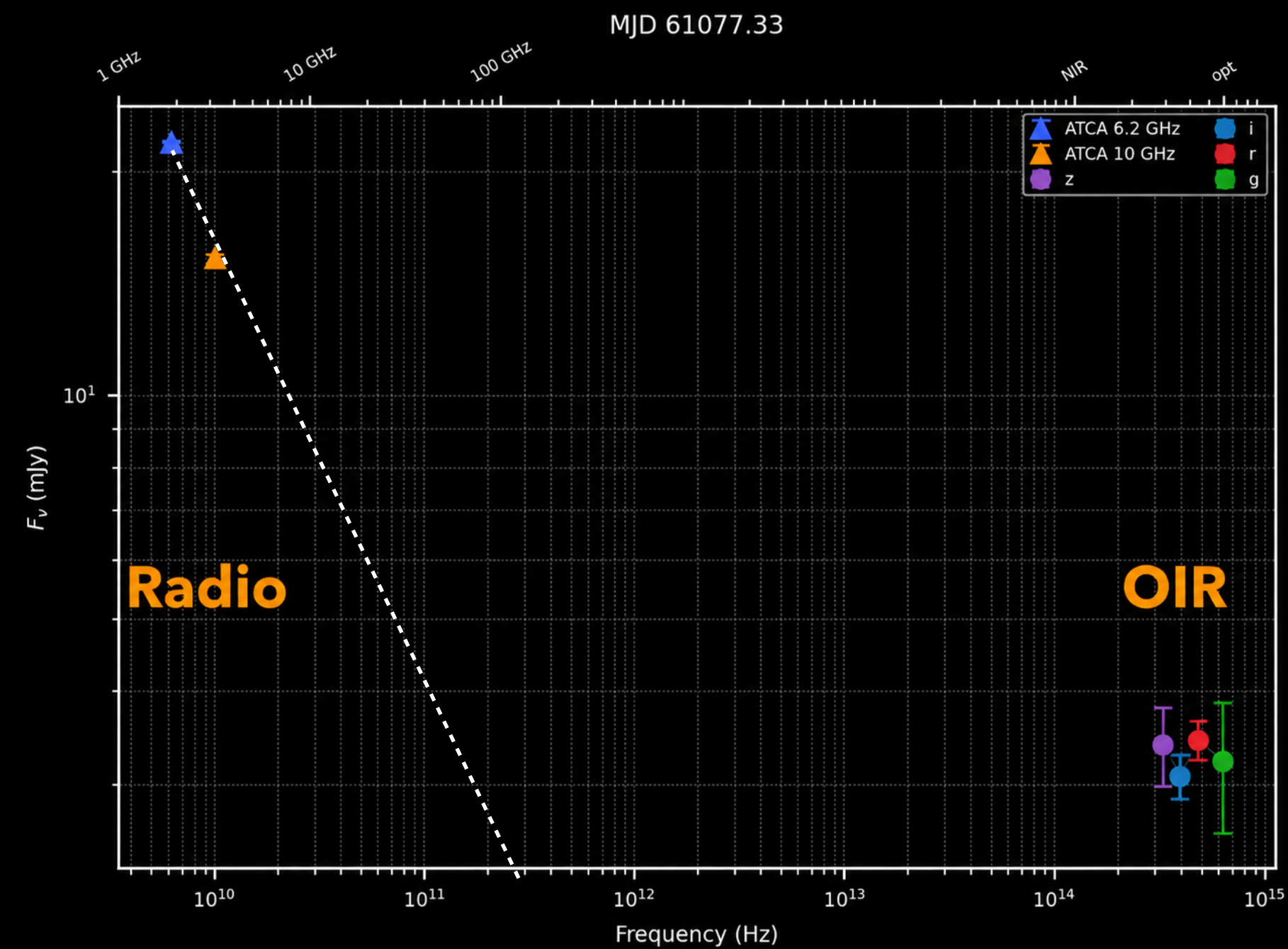
Optical polarization angle rotates at the time of the radio ejection: changes in the origin of the polarization?



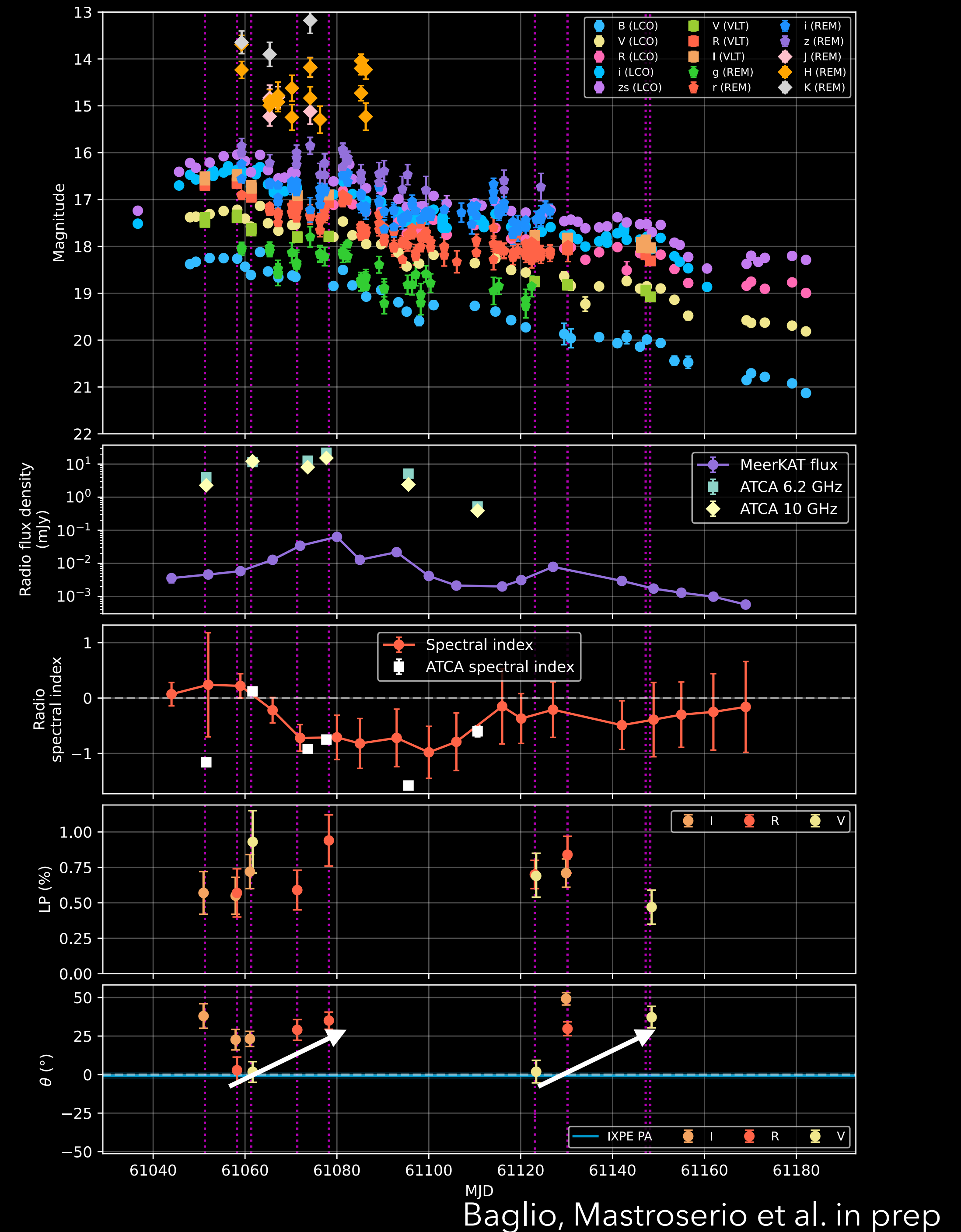
GS 1354-645

Simultaneously with IXPE, optical polarization with VLT (V, R, I filters).

Optical polarization angle rotates at the time of the radio ejection: changes in the origin of the polarization?



From the SED, the jet contribution to the optical is too low!



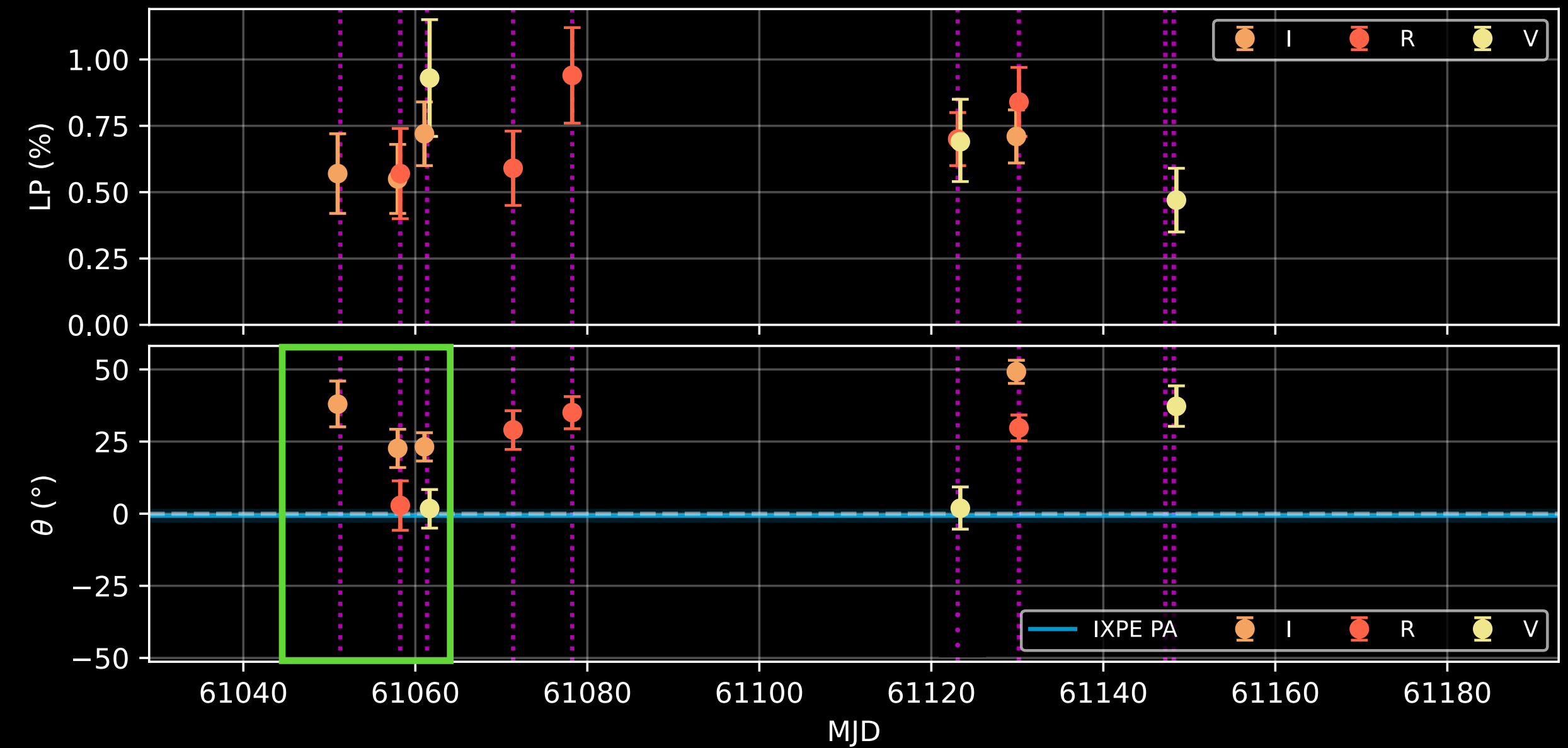
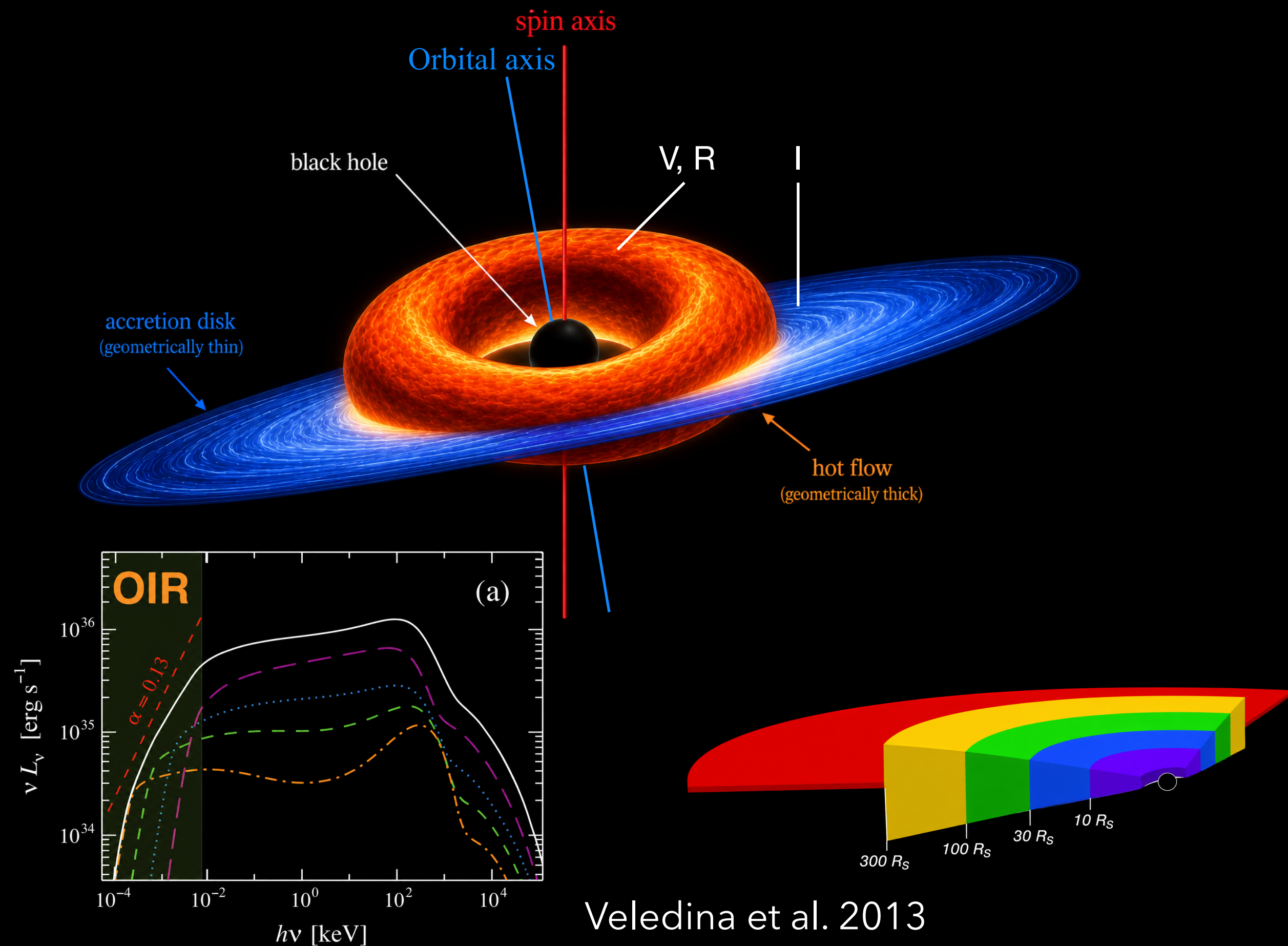
Baglio, Mastroserio et al. in prep

GS 1354-645

Very preliminary: before the ejection, the hotflow is extended and produces synchrotron in V and R.

V and R PA is $\sim$ IXPE

I-band polarization: Thomson scattering in the tilted disc (different PA).



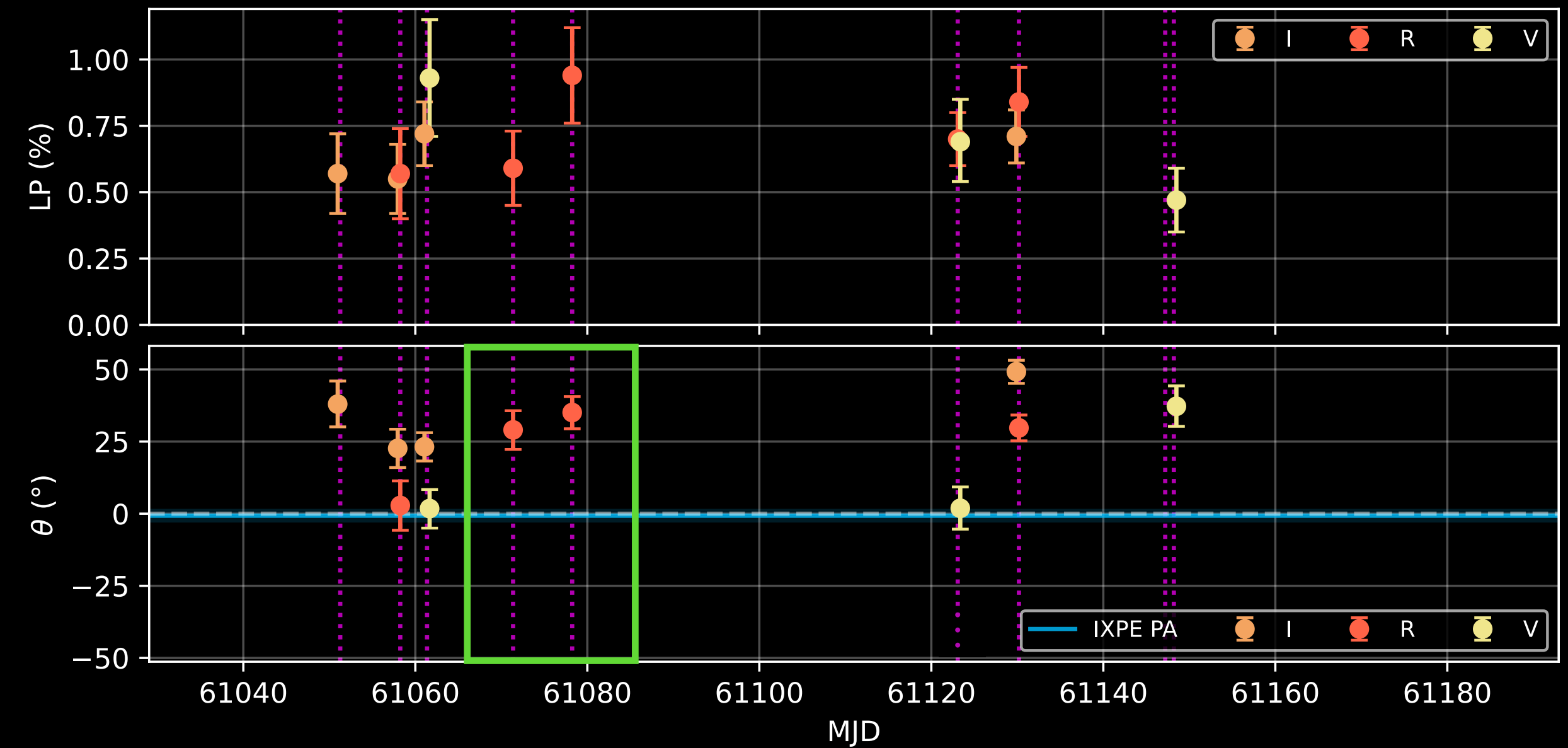
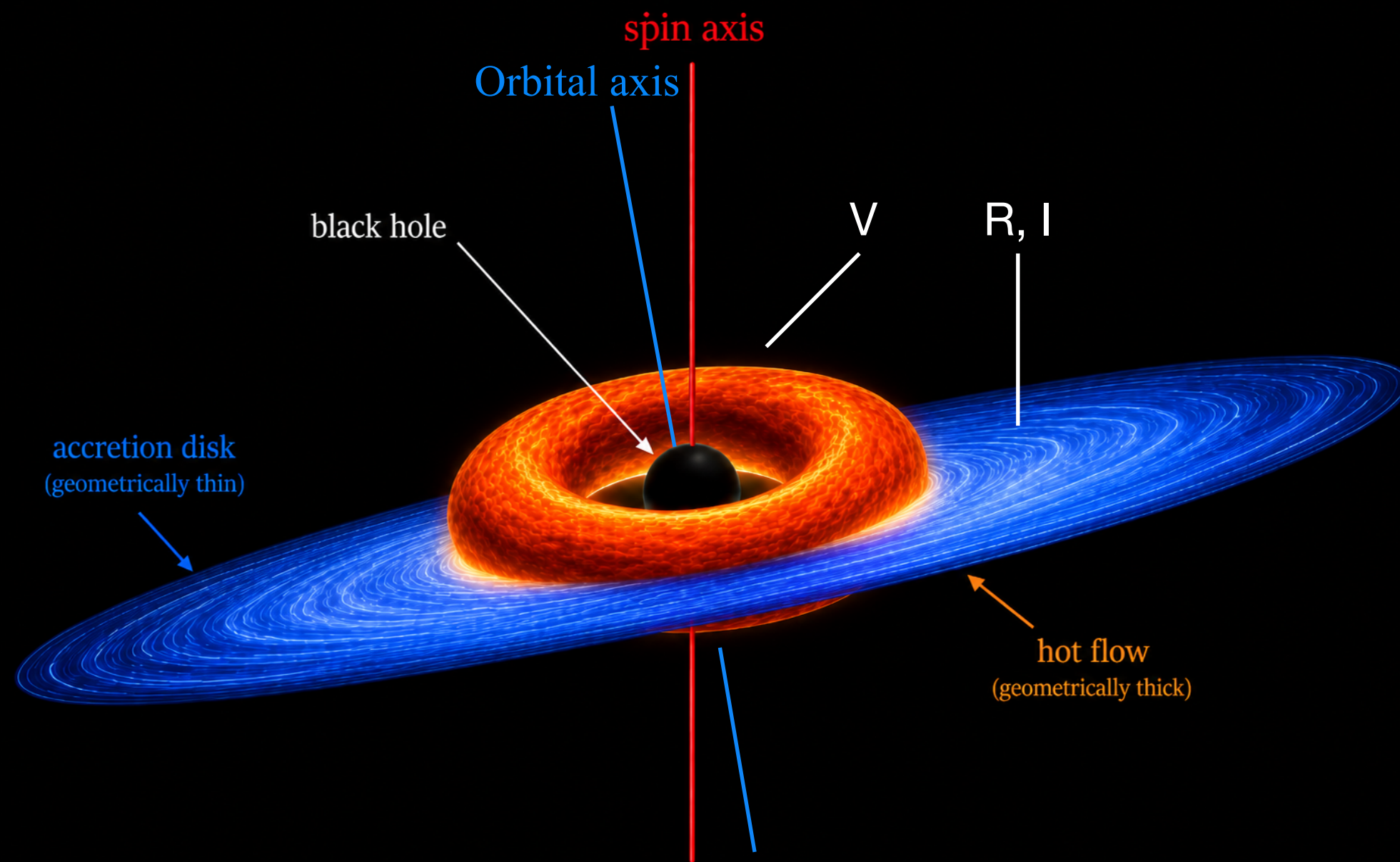
Baglio, Mastroserio et al. in prep

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Baglio, Mastroserio et al. in prep

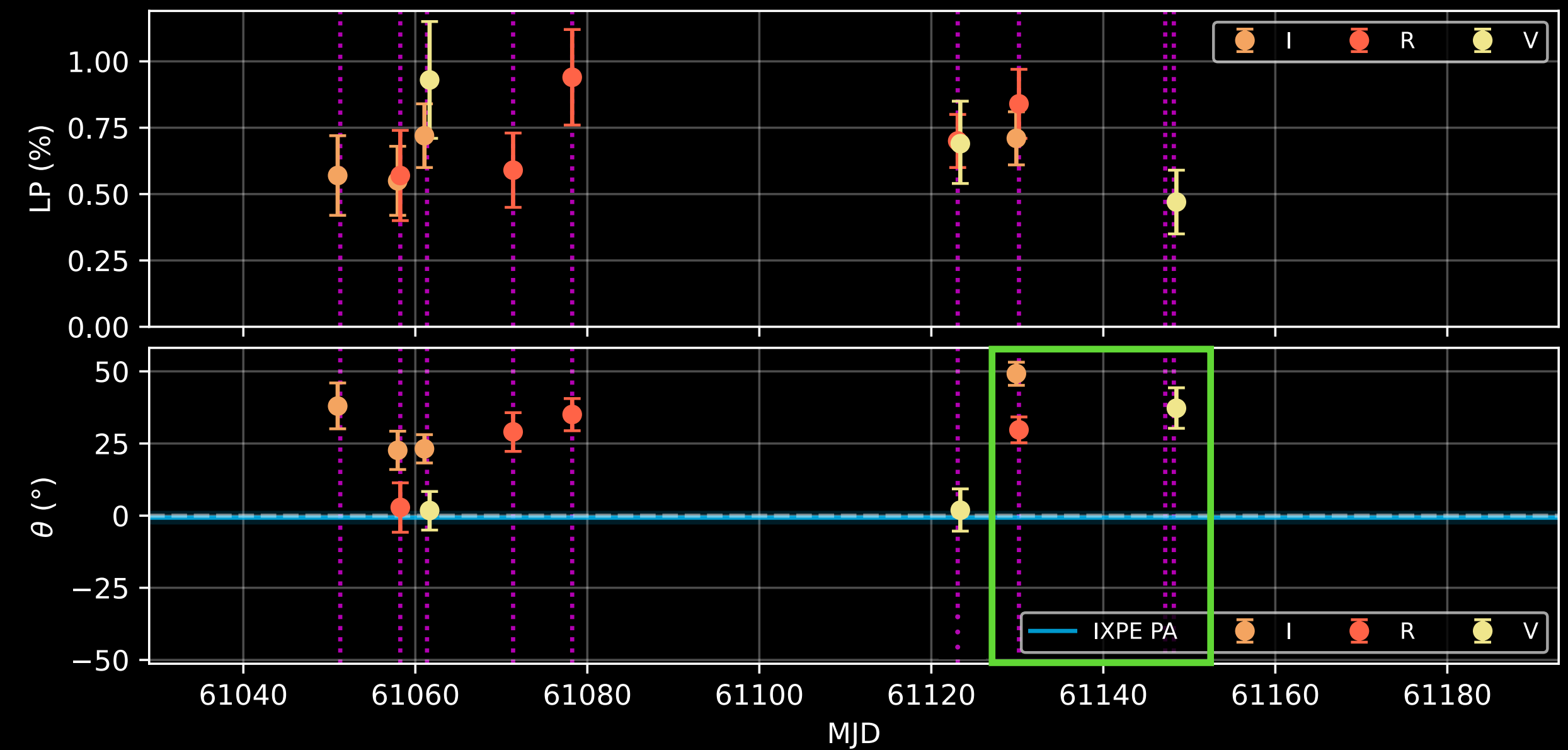
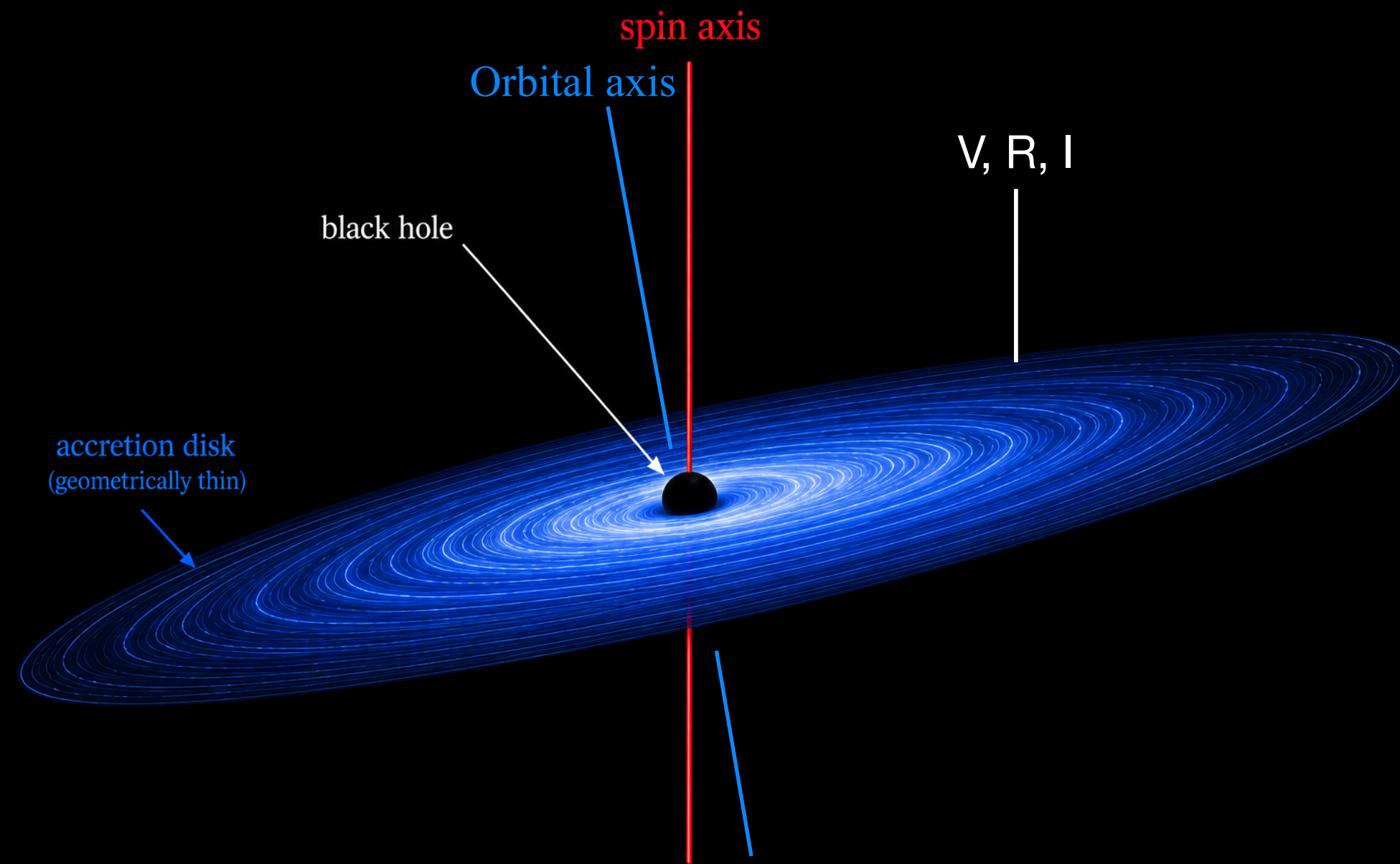
At the transition, the hot flow gets smaller $\rightarrow$ it only emits in V-band, explaining the rotation of the R-band pol. angle.

GS 1354-645

Very preliminary: before the ejection, the hotflow is extended and produces synchrotron in V and R.

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I-band polarization: Thomson scattering in the tilted disc (different PA).



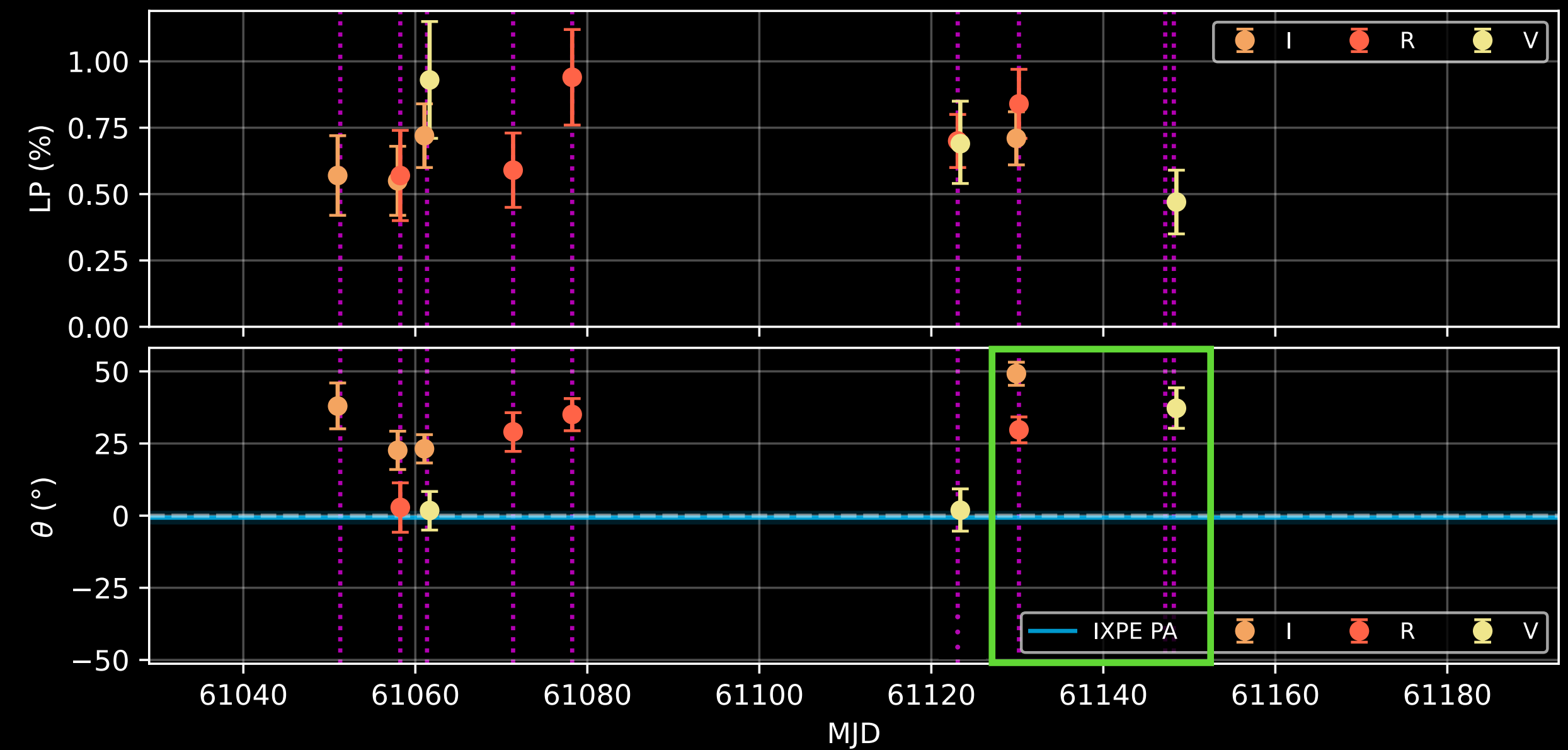
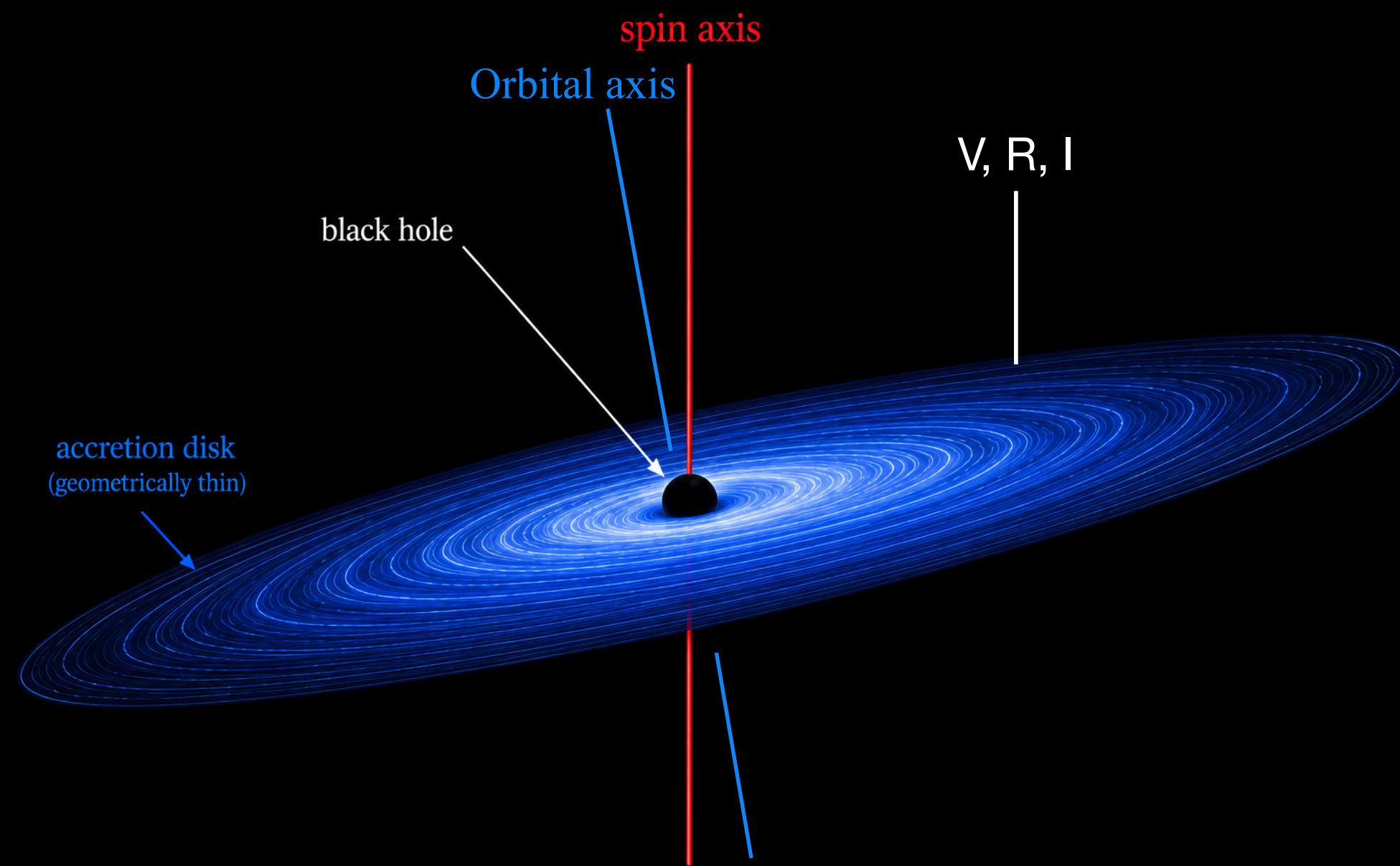
Baglio, Mastroserio et al. in prep

GS 1354-645

Very preliminary: before the ejection, the hotflow is extended and produces synchrotron in V and R.

V and R PA is $\sim$ IXPE

I-band polarization: Thomson scattering in the tilted disc (different PA).



Baglio, Mastroserio et al. in prep

In the soft state, optical comes entirely from the disc: complete rotation of PA.

Conclusions

Optical and NIR polarization can have different origin:

Thomson scattering in the disk atmosphere/wind/outflow

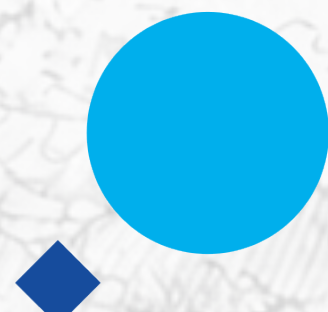
Synchrotron from a jet

Synchrotron from the extended photosphere of the hot flow

Determining the origin of polarization can be tricky, but helps obtaining information on the geometry of the system and on the configuration of the magnetic field in jets

Recent results of X-ray polarization of XRBs have proved crucial to determine the geometry of XRBs and of the inner accretion flow

Optical and X-ray polarization can work in synergy to understand the geometry of LMXBs.



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THANK YOU!