



Highs and Lows of a transitional MSP

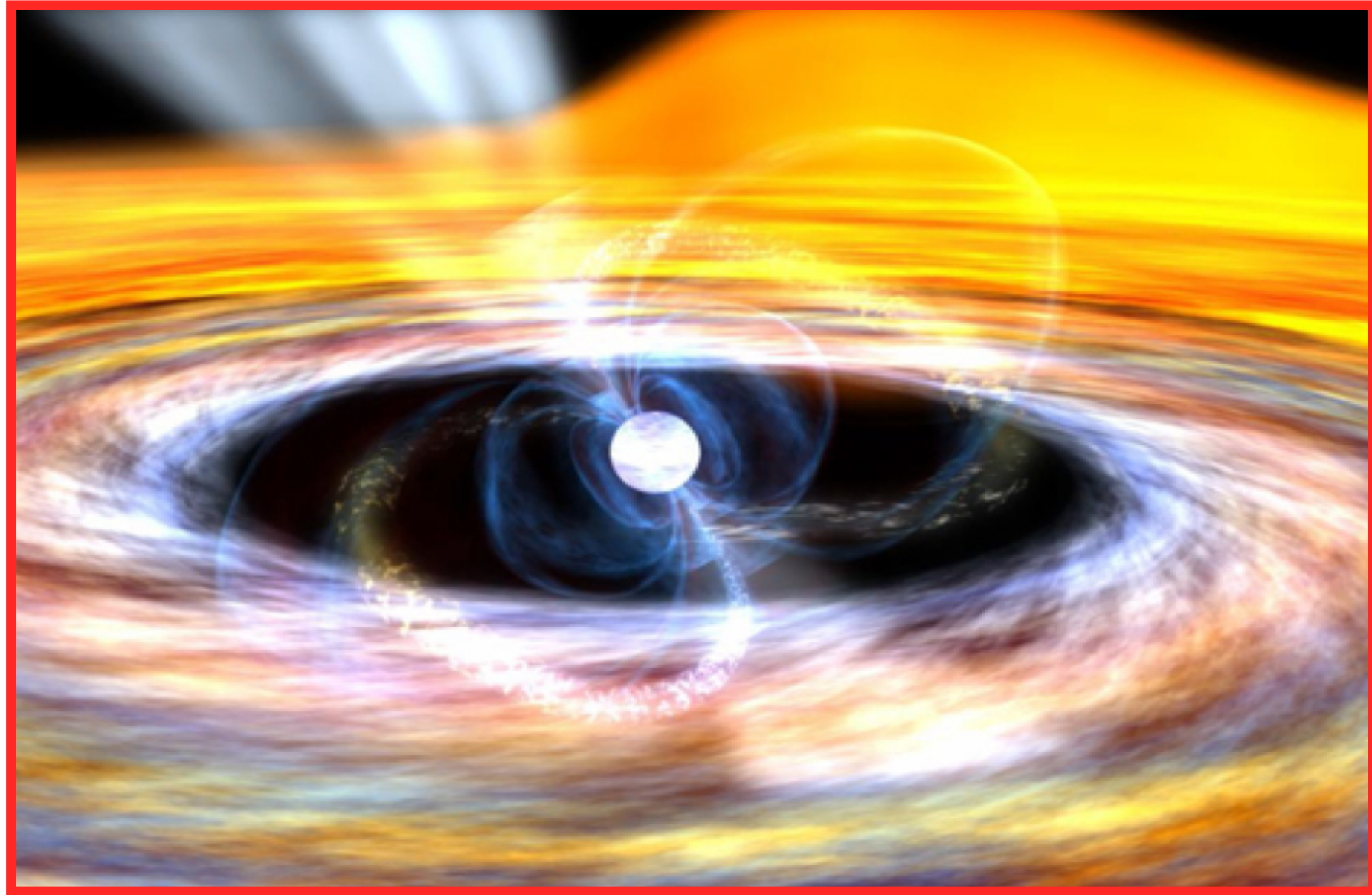
The ultimate campaign on PSR J1023+0038

M. Cristina Baglio

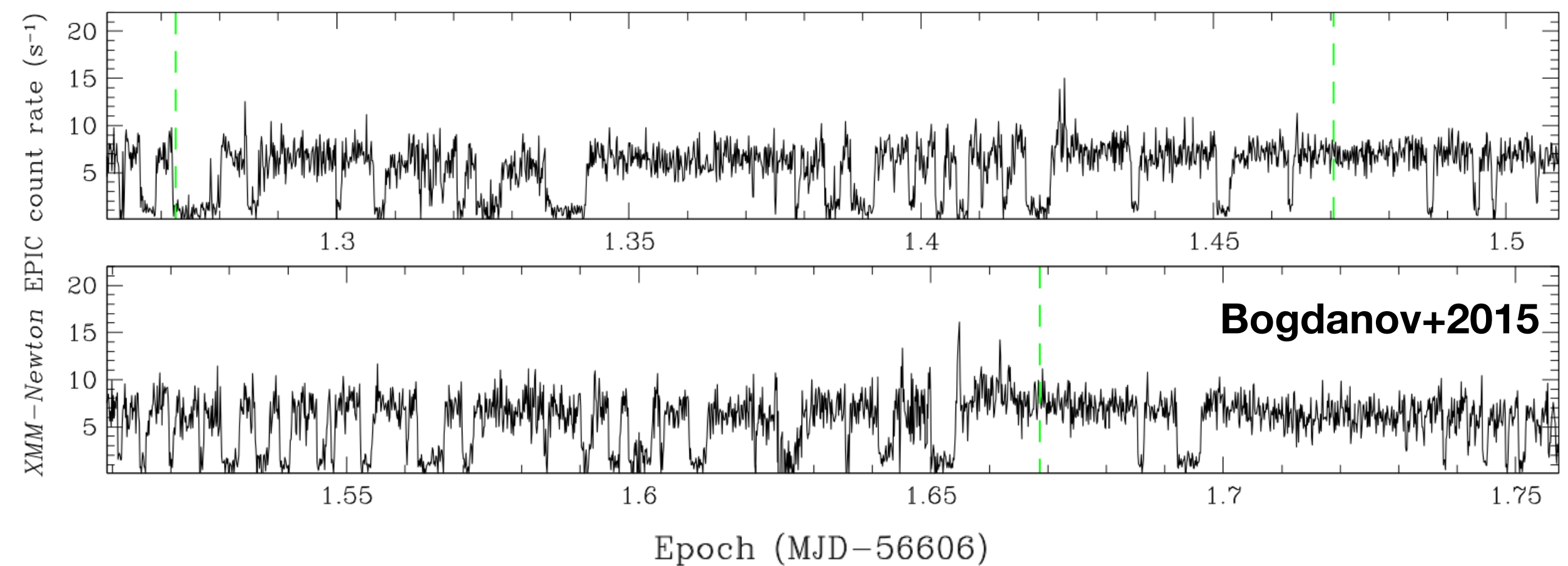
New York University of Abu Dhabi
INAF- Osservatorio Astronomico di Brera (Merate)

Collaborators: **F. Coti Zelati (ICE, CSIC)**, S. Campana, P. D'Avanzo, S. Covino (INAF - OAB), A. Miraval Zanon, A. Papitto, P. Casella (INAF -OAR), D. M. Russell (NYU Abu Dhabi)

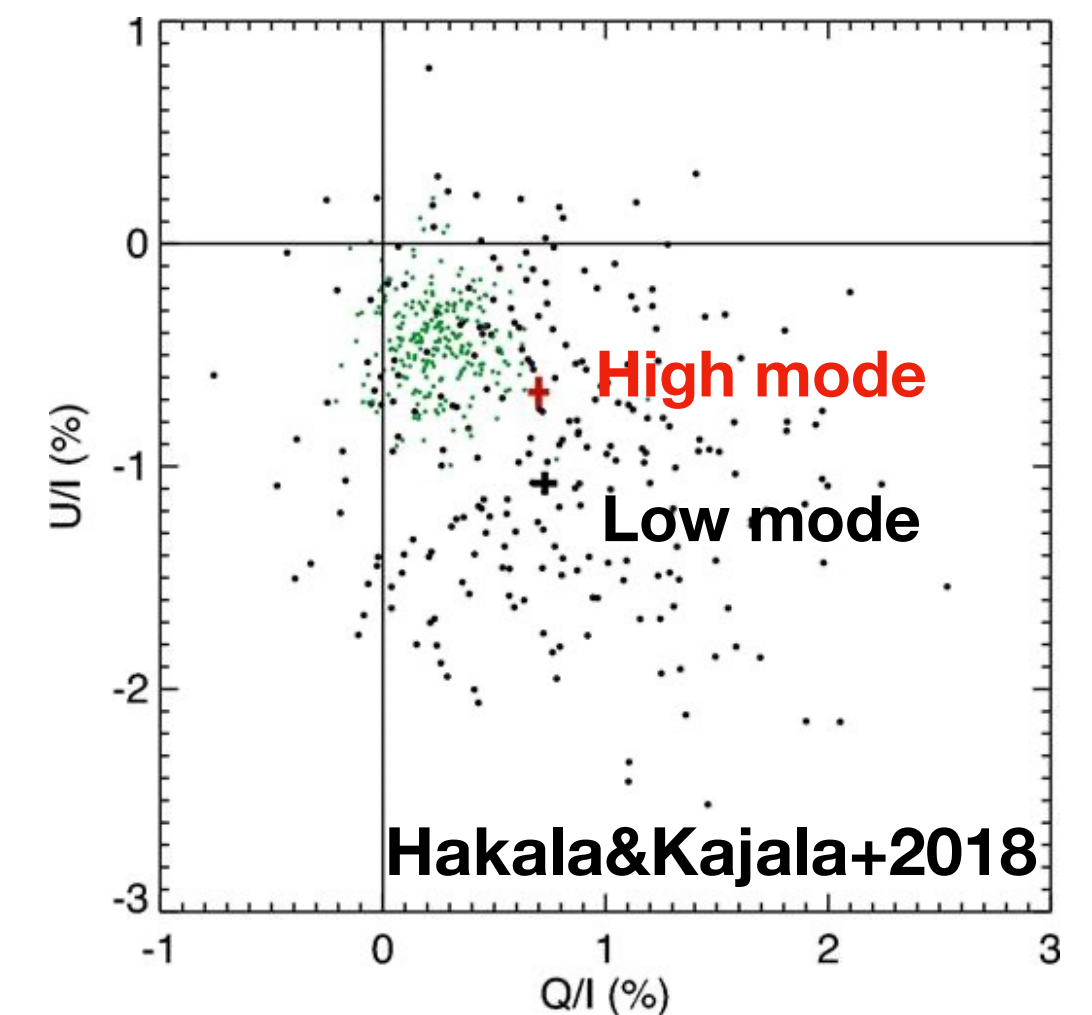
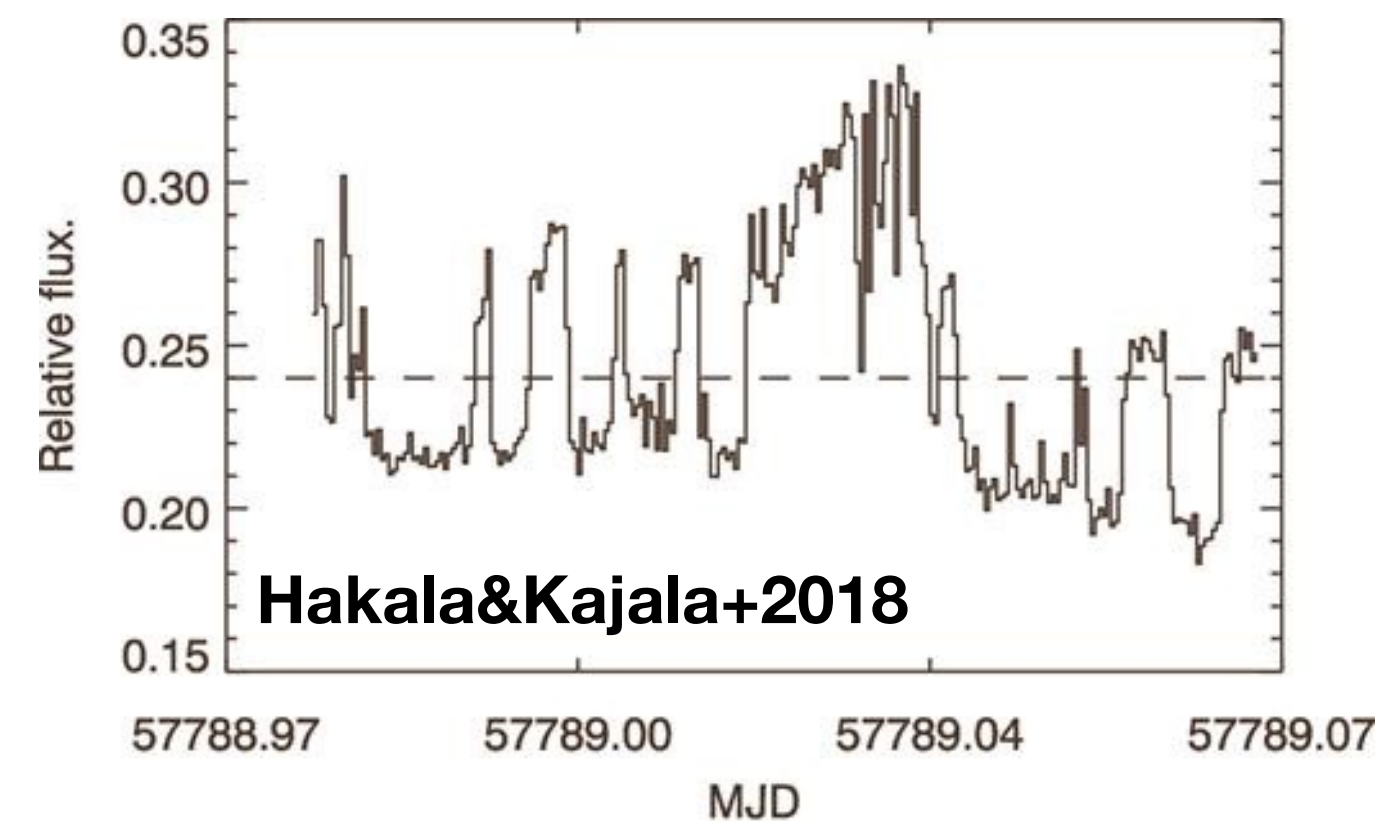
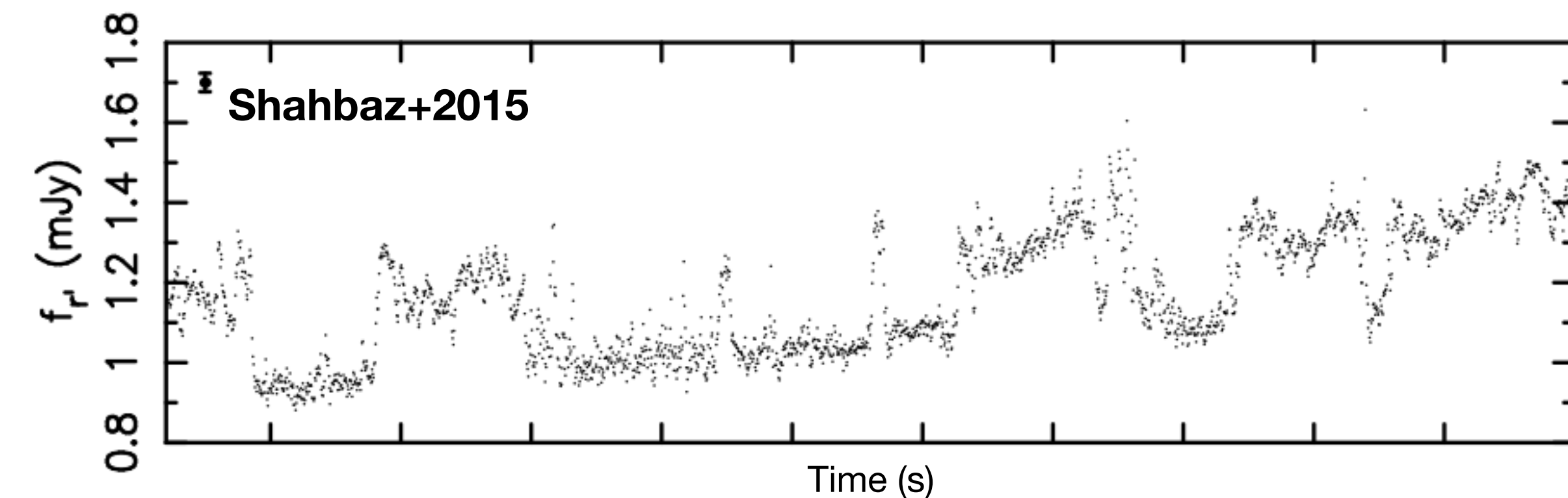
Accretion states in tMSPs



Both **PSR J1023+0038** and **XSS J12270-4859** show transitions on a timescale of ~ 10 s between a *low* ($L_x \sim 10^{33}$ erg s $^{-1}$) and a *high* ($L_x \sim 7 \times 10^{33}$ erg s $^{-1}$) mode. Flares are also observed ($L_x \sim 10^{34}$ erg s $^{-1}$).
Bogdanov+2015, Campana+2016



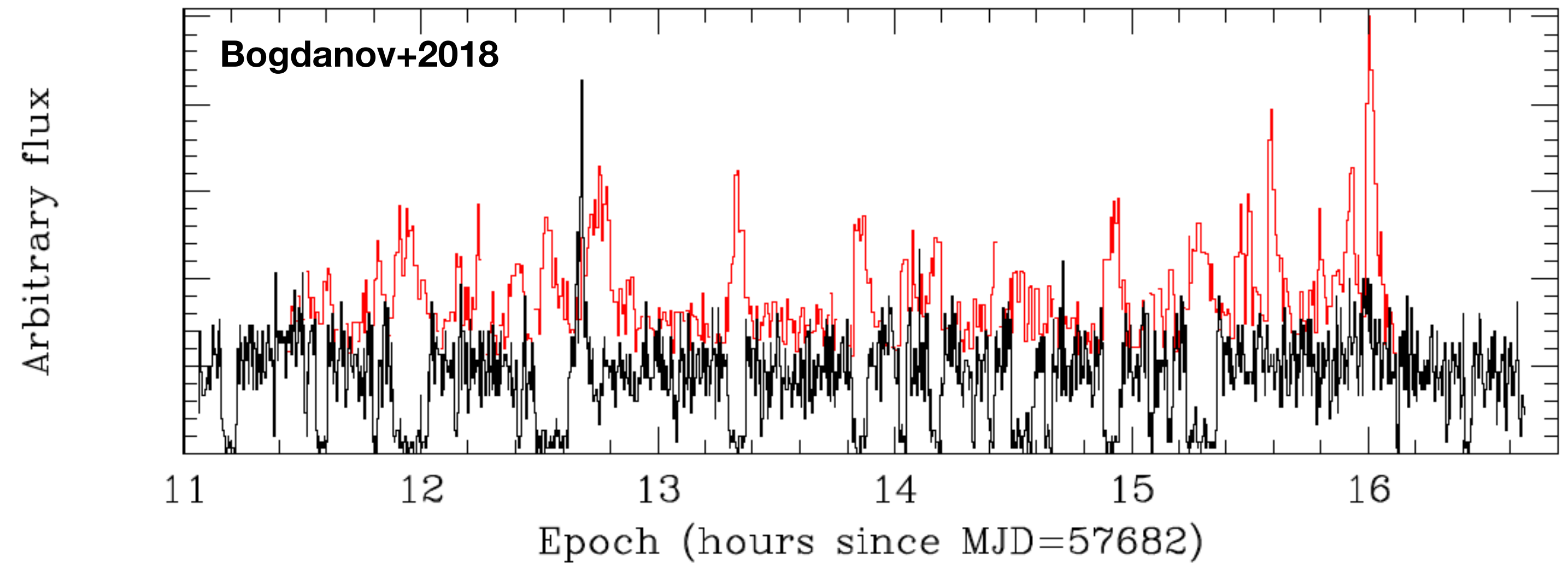
Pulsations detected during high modes only.
Similar transitions detected also in NIR, optical and optical polarization.



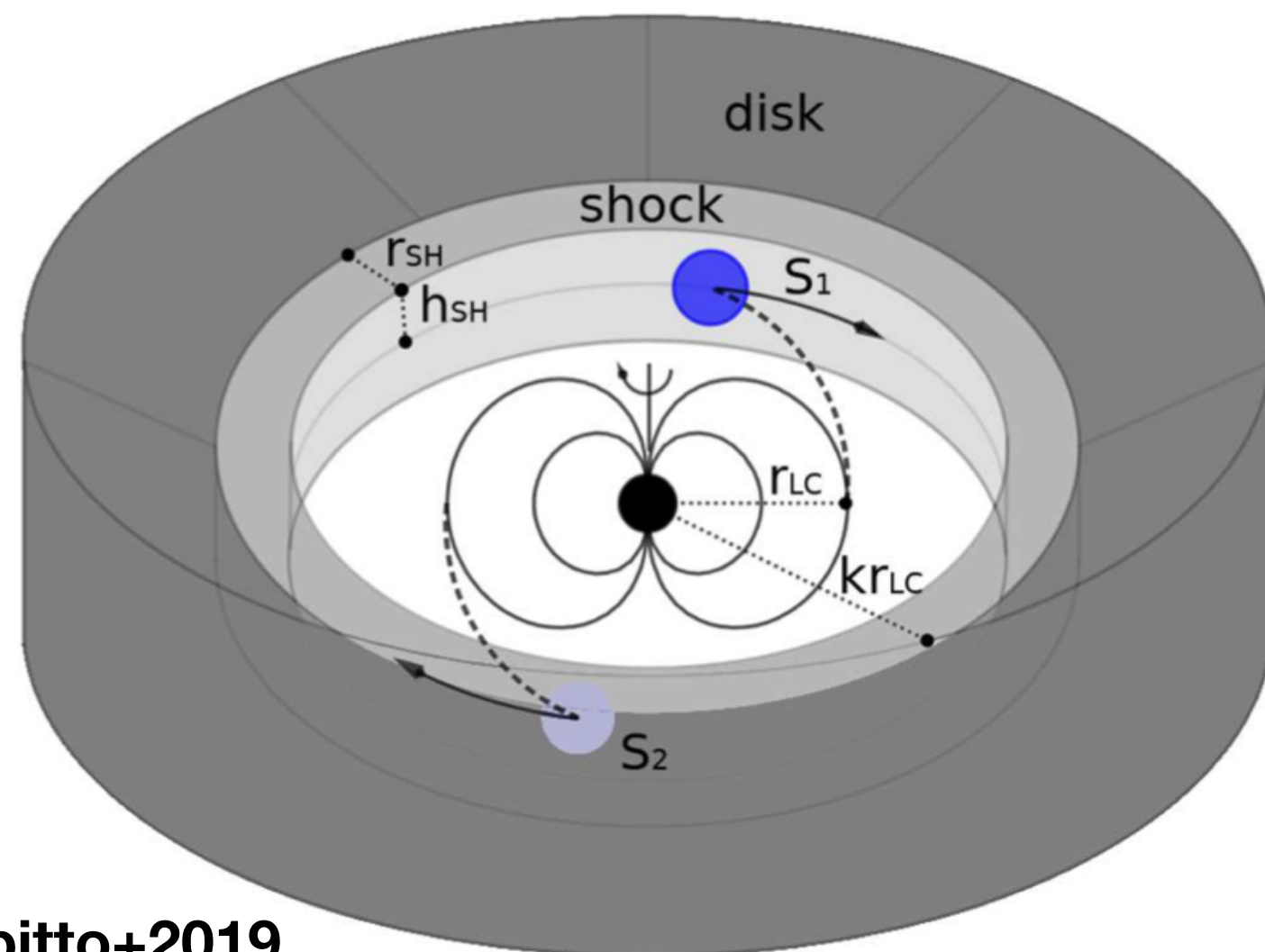
PSR J1023: what else we already know

RADIO continuum emission with flat spectral shape: possible compact self-absorbed jet (Deller+2015).

RADIO flares during low X-ray modes: possible ejection of optically thin plasmoids (Bogdanov+2018).



New important discovery: optical ms pulsations (see Filippo, Alessandro, Arianna talks) with SiFAP2 and Aqueye+



The radio pulsar is always active

HIGH MODE

The pulsar wind interacts with the disc

A shock is generated

Coherent pulsations from optical to X-rays are produced

LOW MODE

The shock moves outside the lc radius

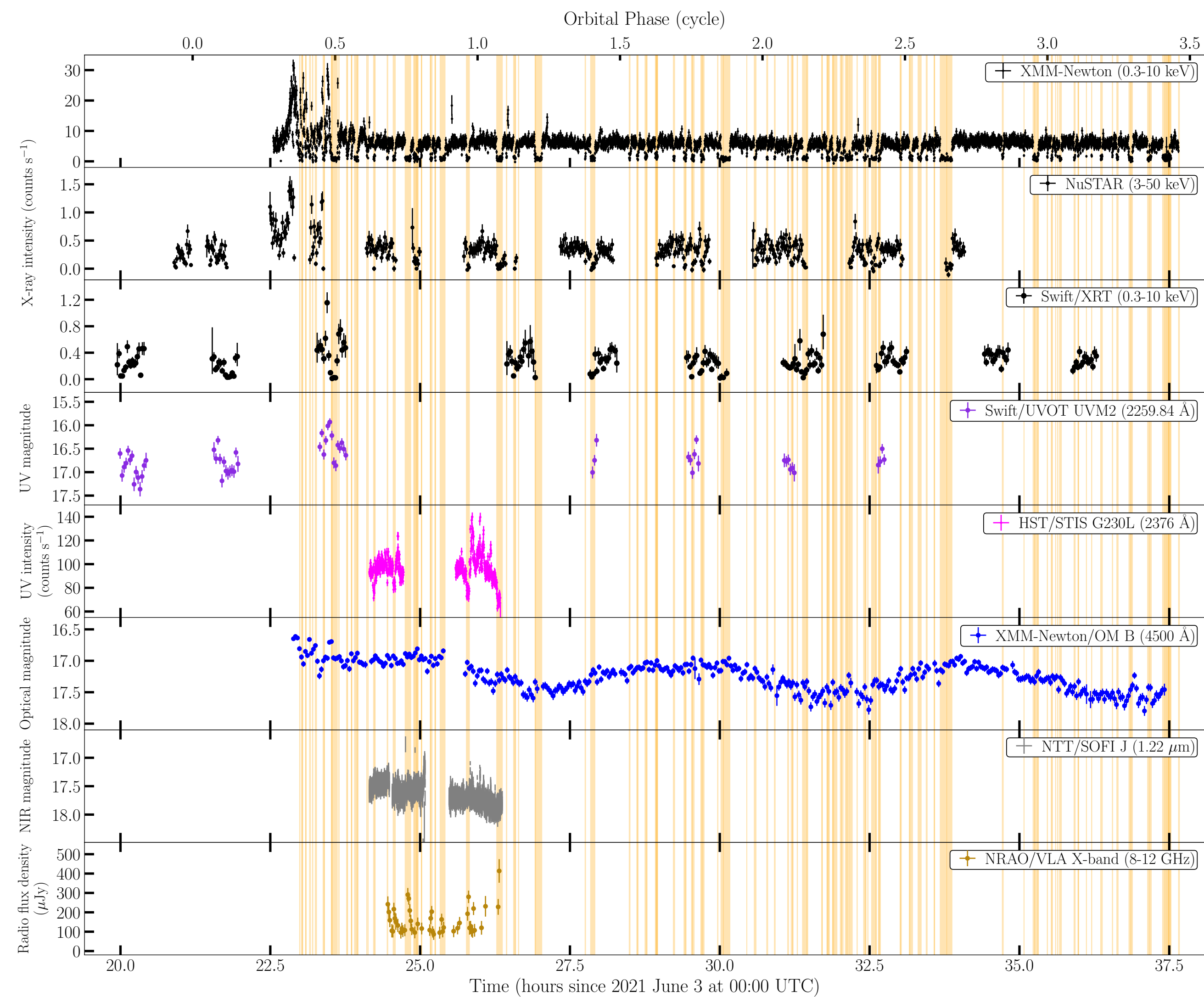
No pulsations are observed

FLARING MODE

The region of shock becomes bigger

The ultimate campaign!

2 nights of monitoring in June 2021, many facilities involved.

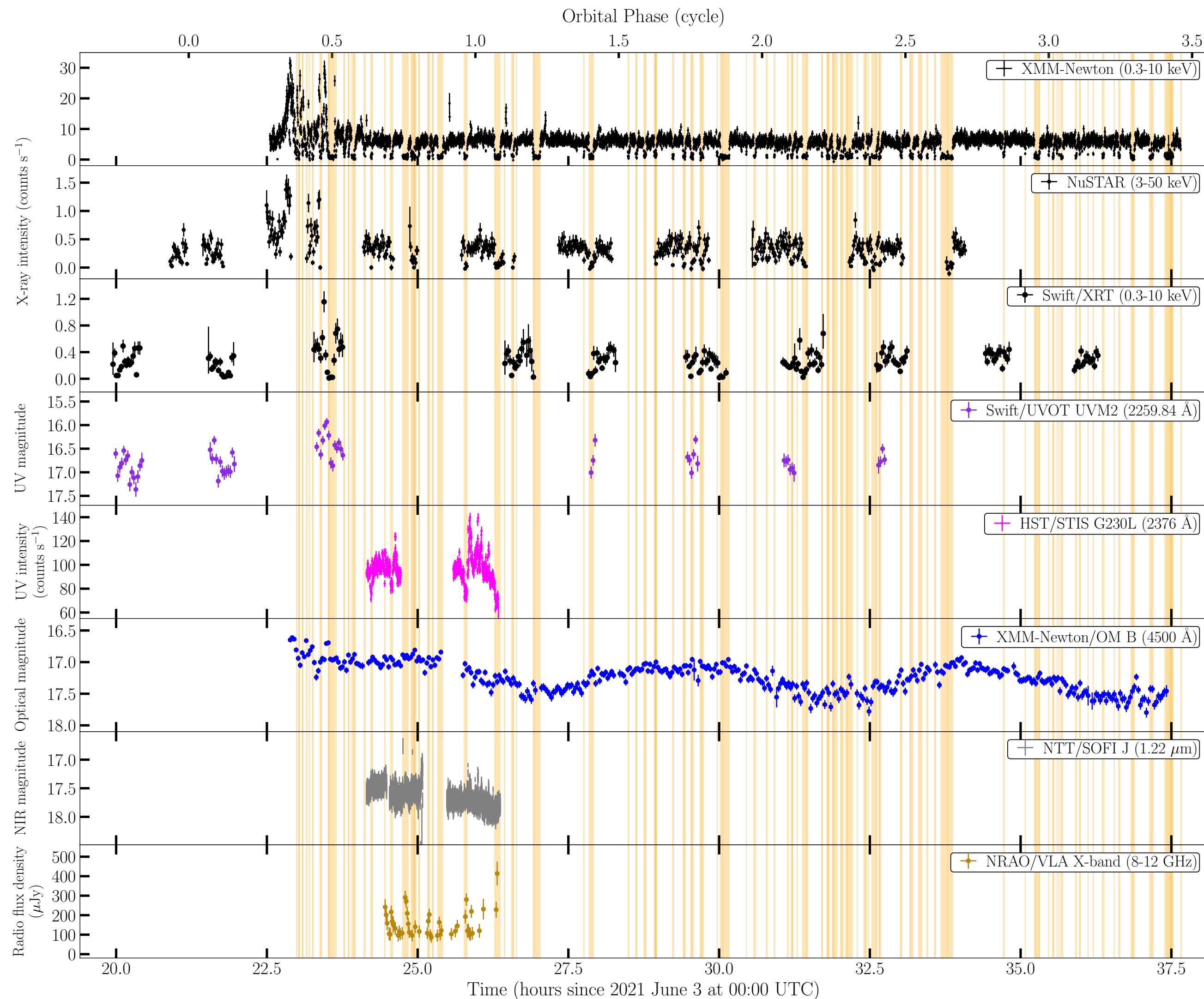


NIGHT1:

- XMM-Newton (0.3-10 keV)
- NuSTAR
- Swift/XRT
- Swift/UVOT
- HST/STIS
- XMM-Newton/OM B-band
- NTT/SOFI J-band
- VLA X-band (8-12 GHz)

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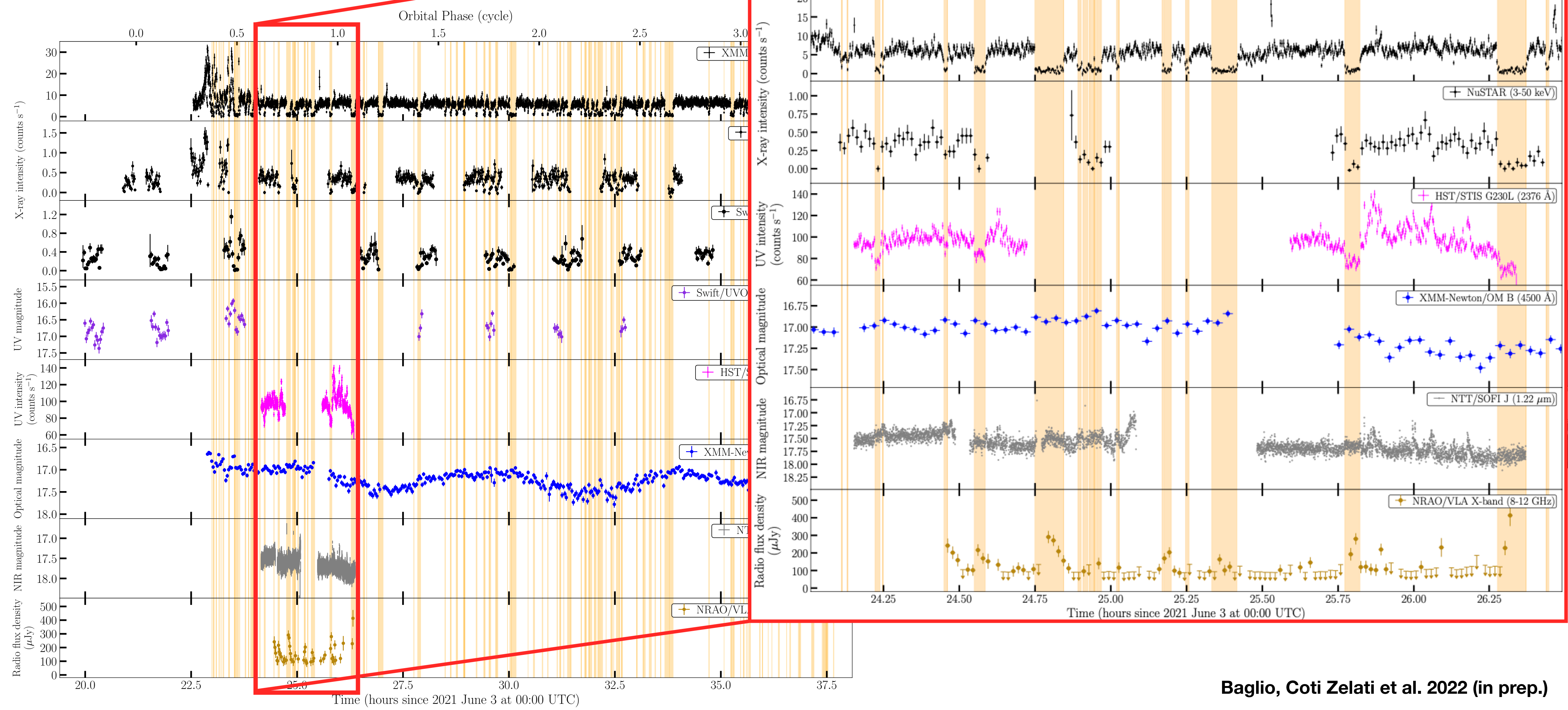
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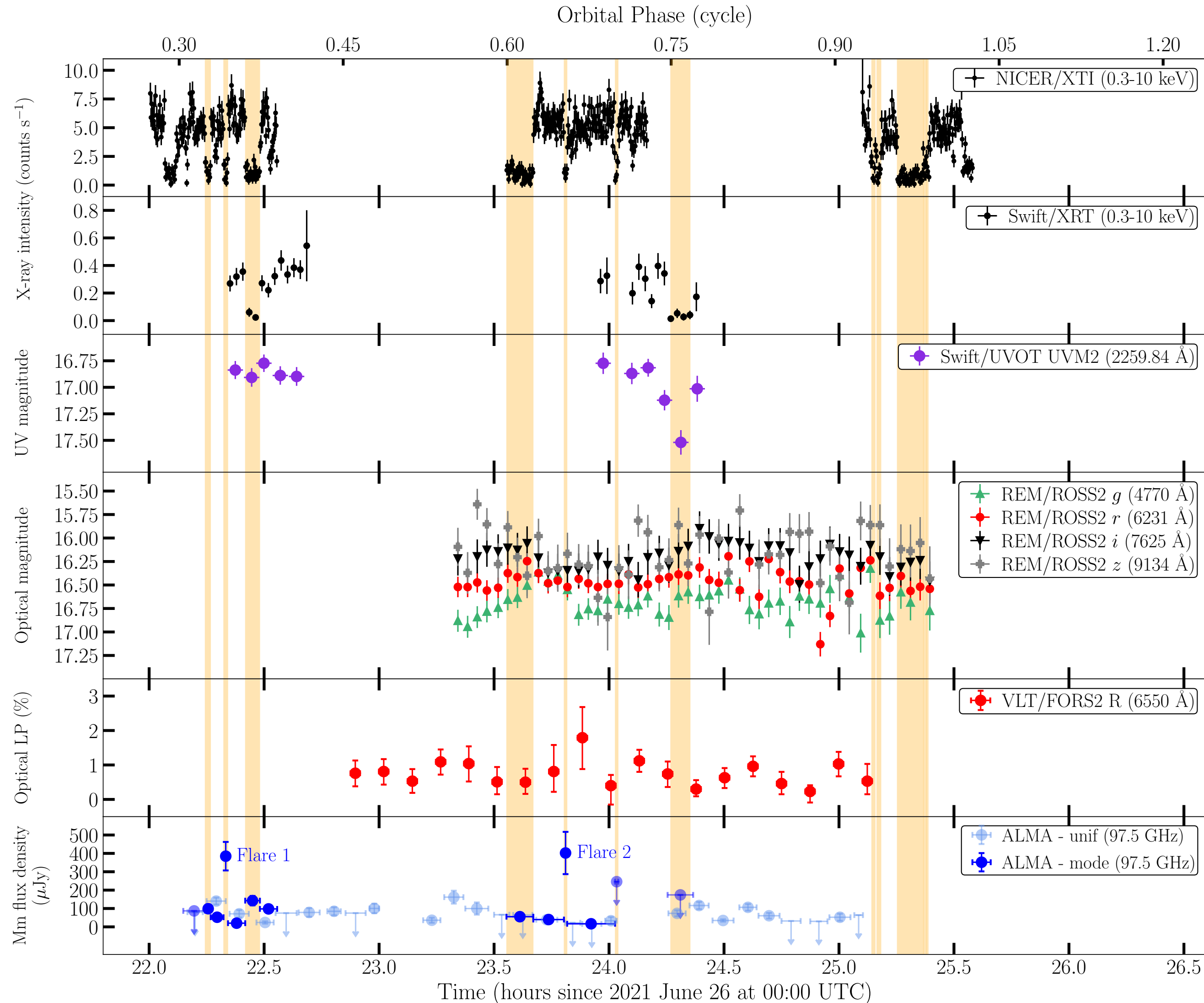
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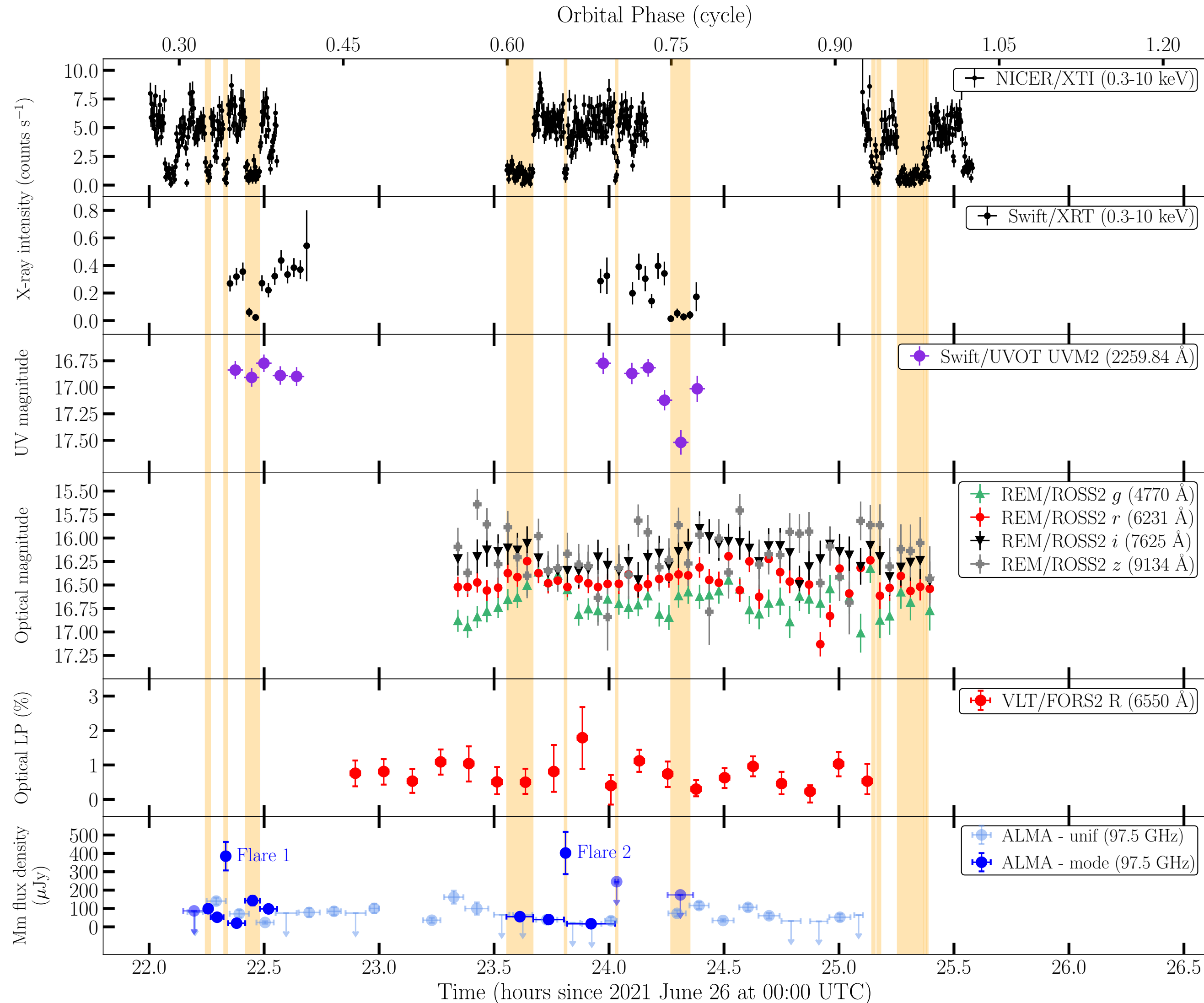


NIGHT2:

- NICER (0.3-10 keV)
- Swift/XRT
- Swift/UVOT
- REM/ROSS2, REMIR
- VLT (FORS2 polarimeter)
- ALMA

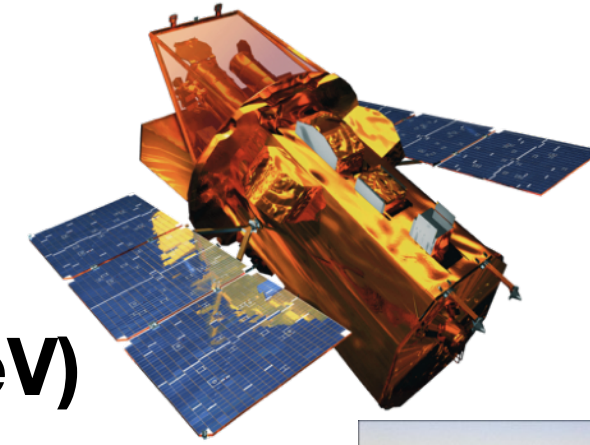
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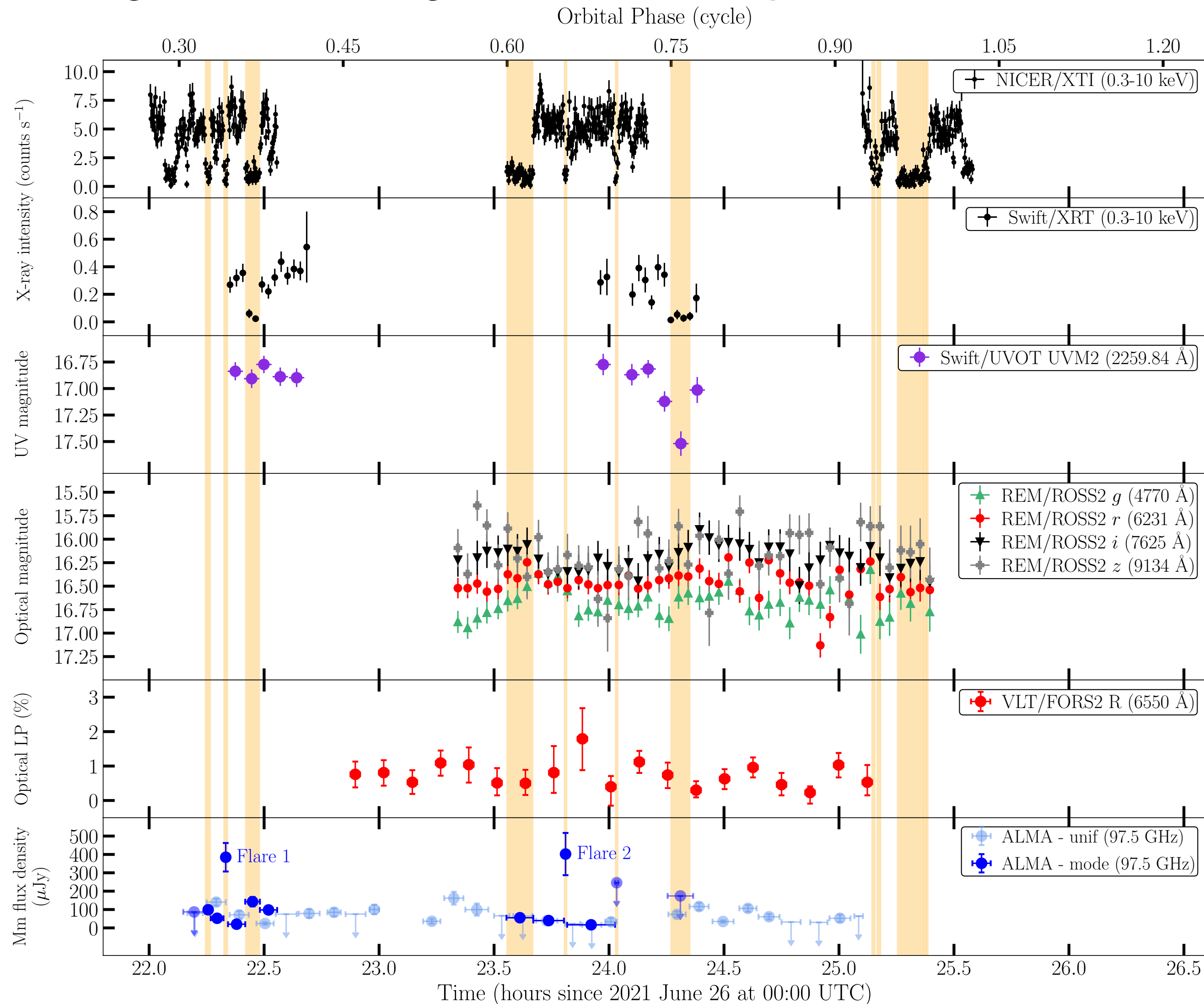
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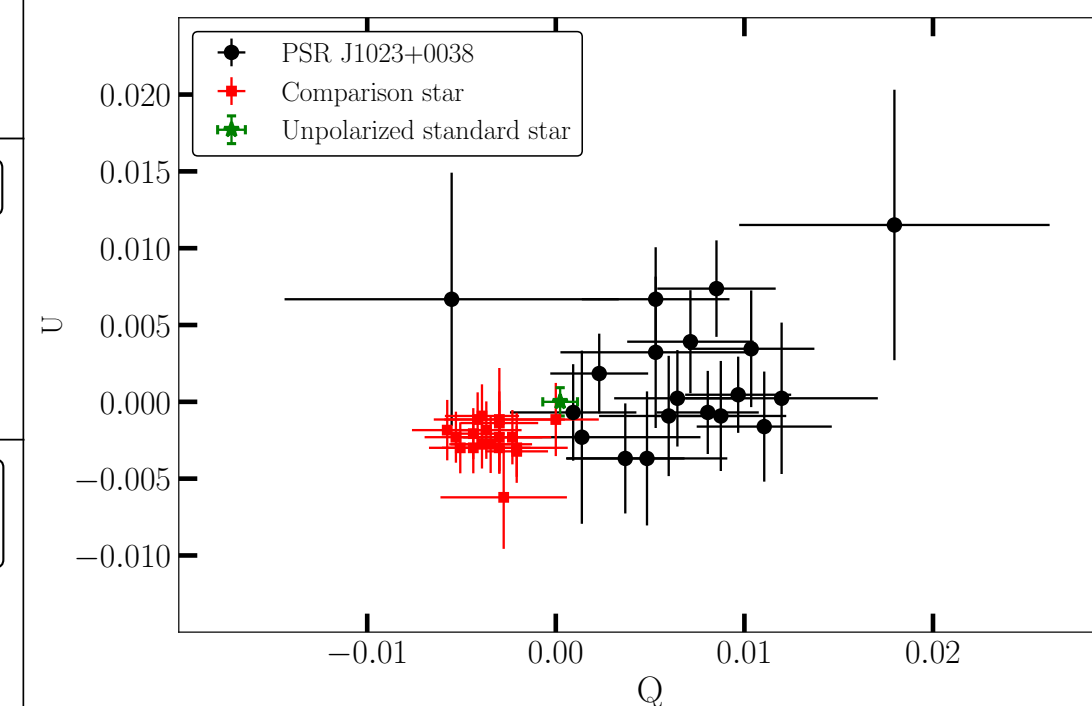
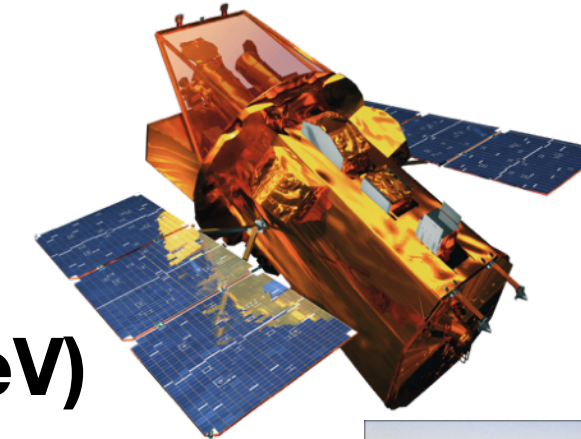
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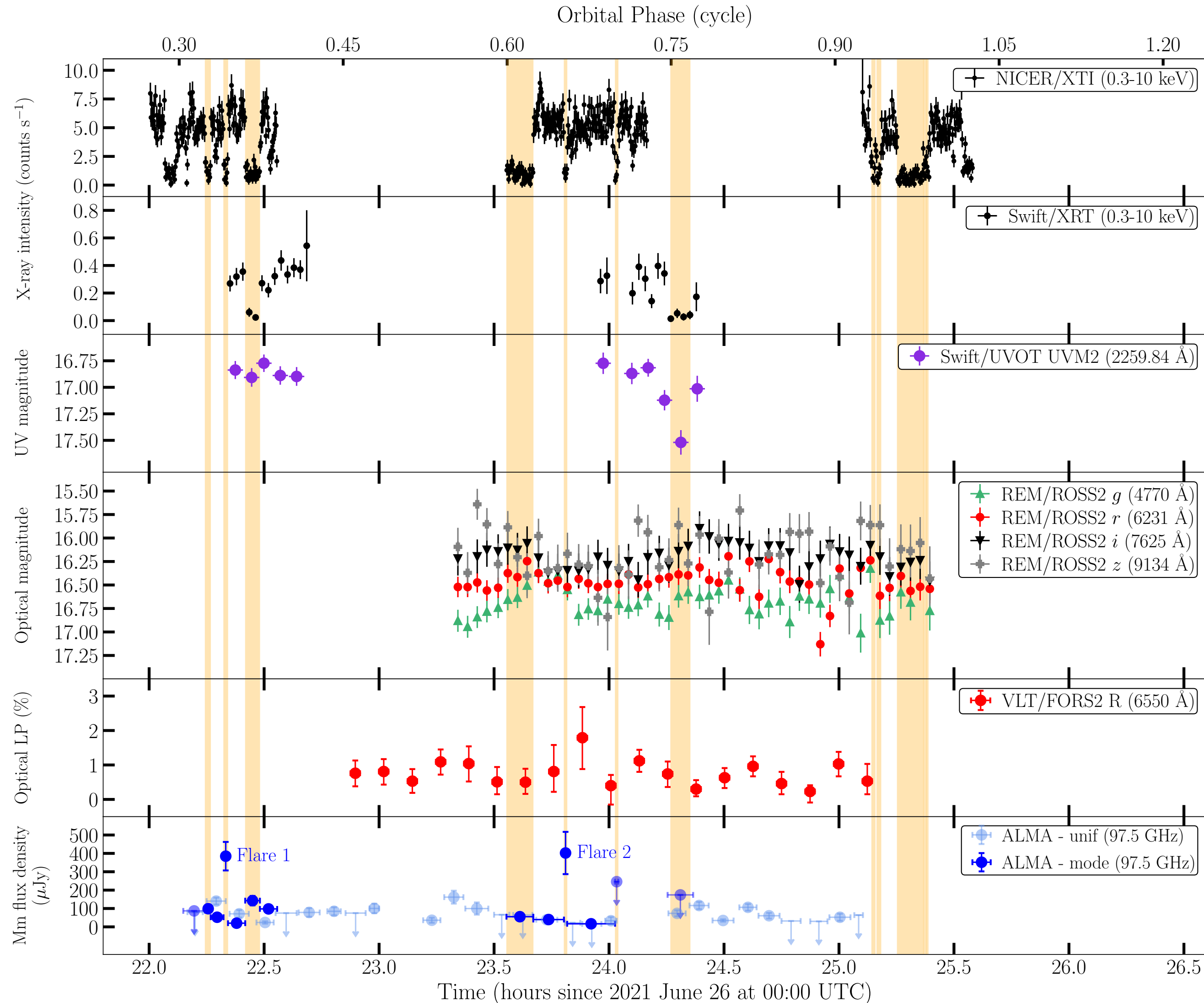
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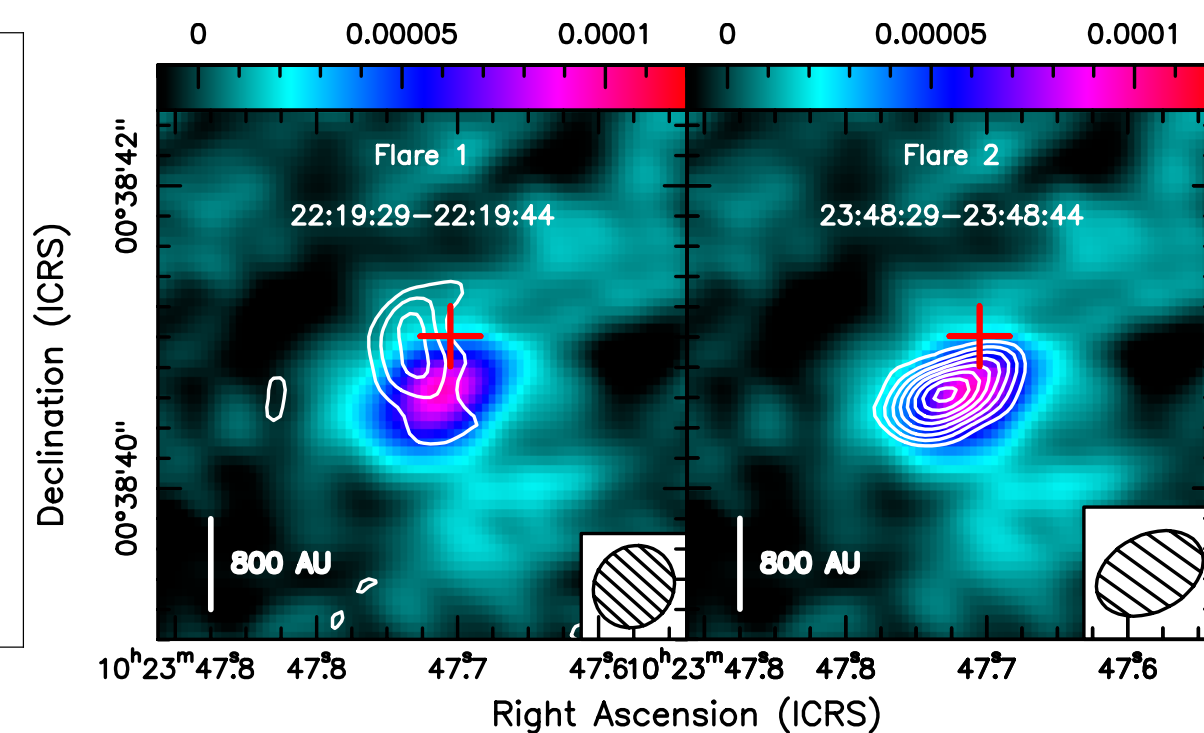
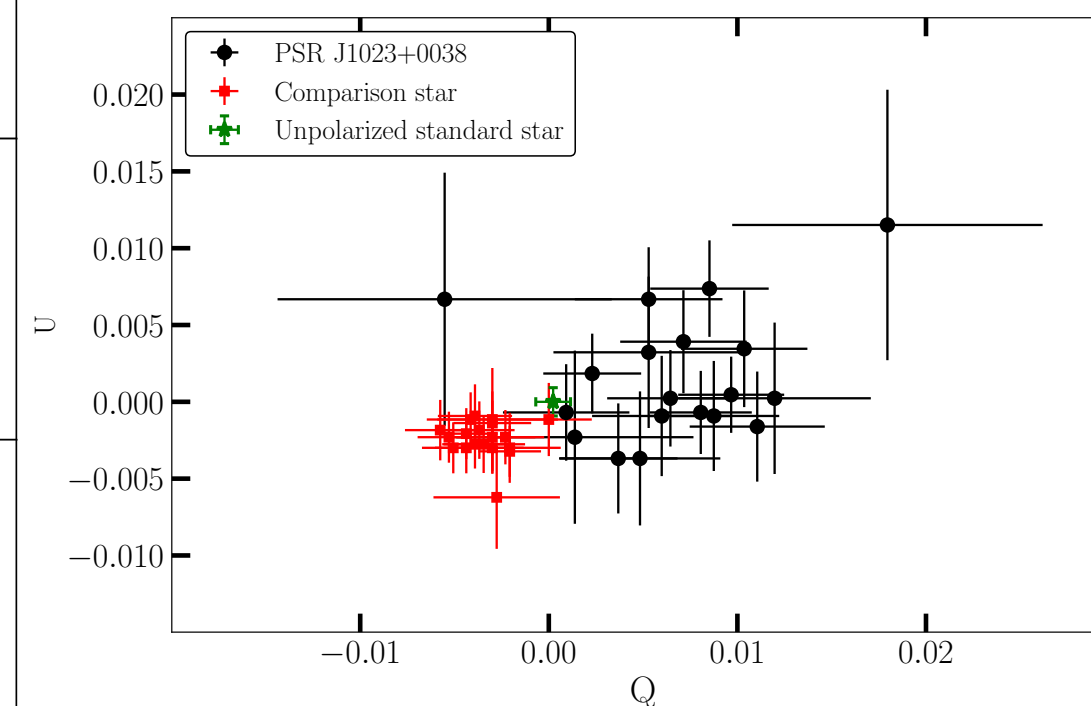
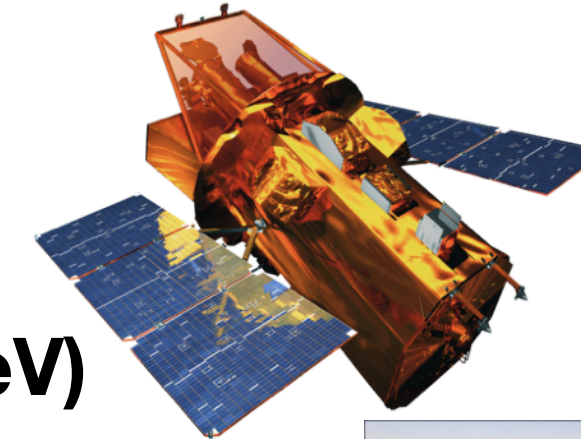
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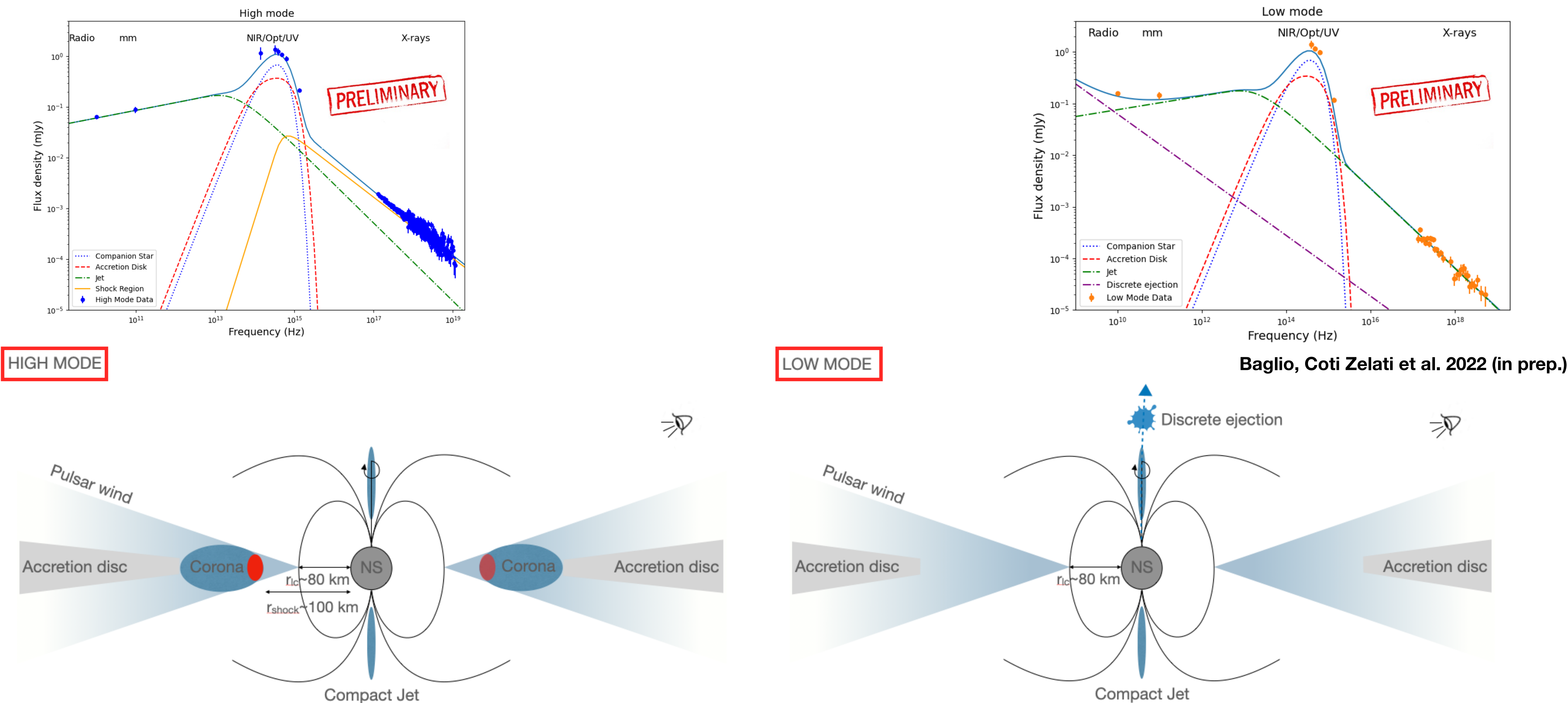
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Baglio, Coti Zelati et al. 2022 (in prep.)

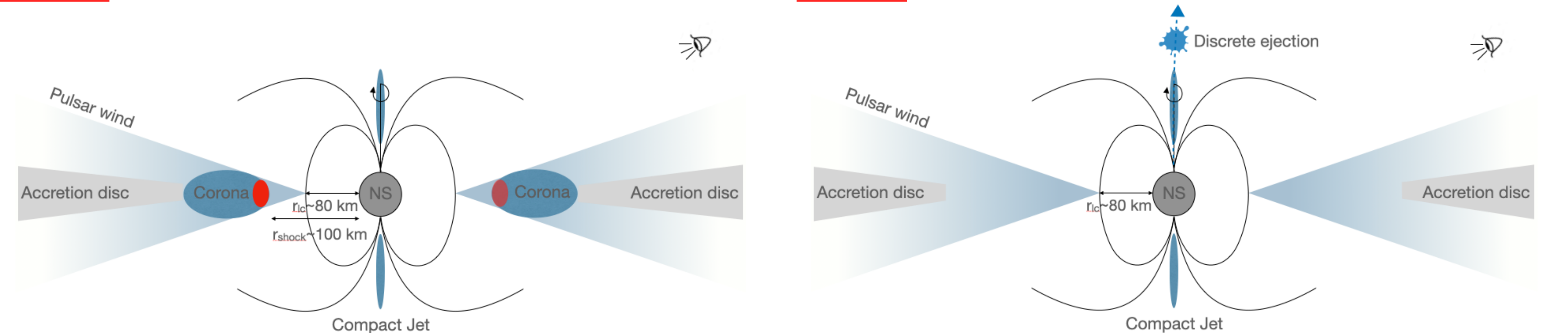
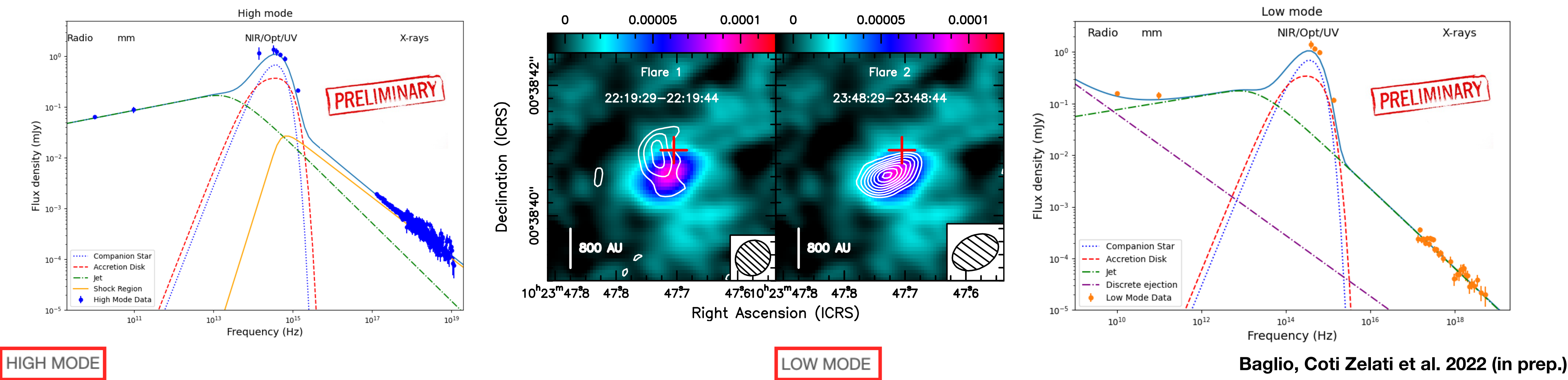
Highs and lows: a possible scenario



Baglio, Coti Zelati et al. 2022 (in prep.)

The shock moves out (of a factor ~ 20): its contribution in the X-rays is negligible.

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Polarization: possible origins & predictions

1 - Optically thin emission from the jet

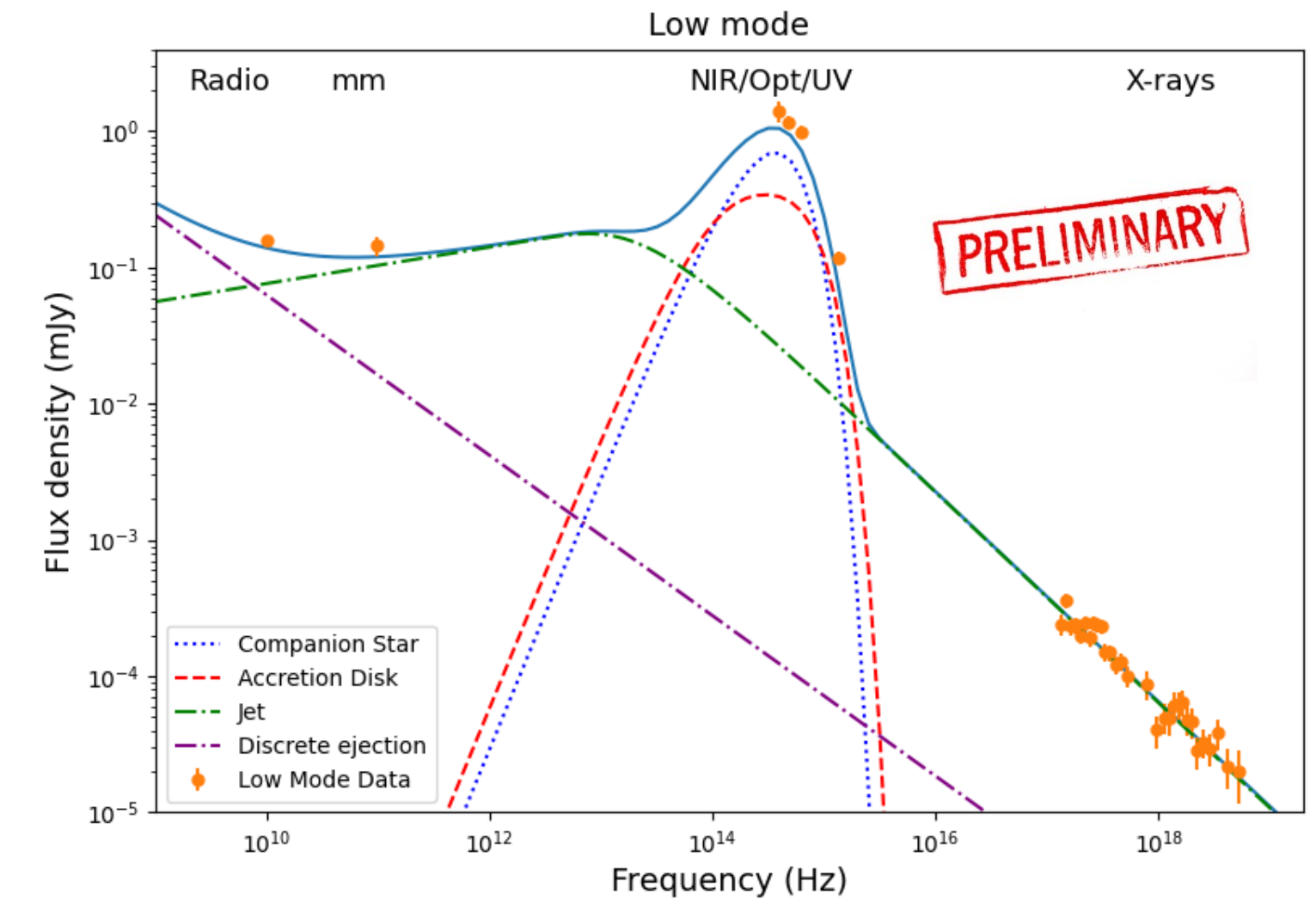
Low average polarization (0.92%).

The compact jet is contributing up to 3% in r-band.

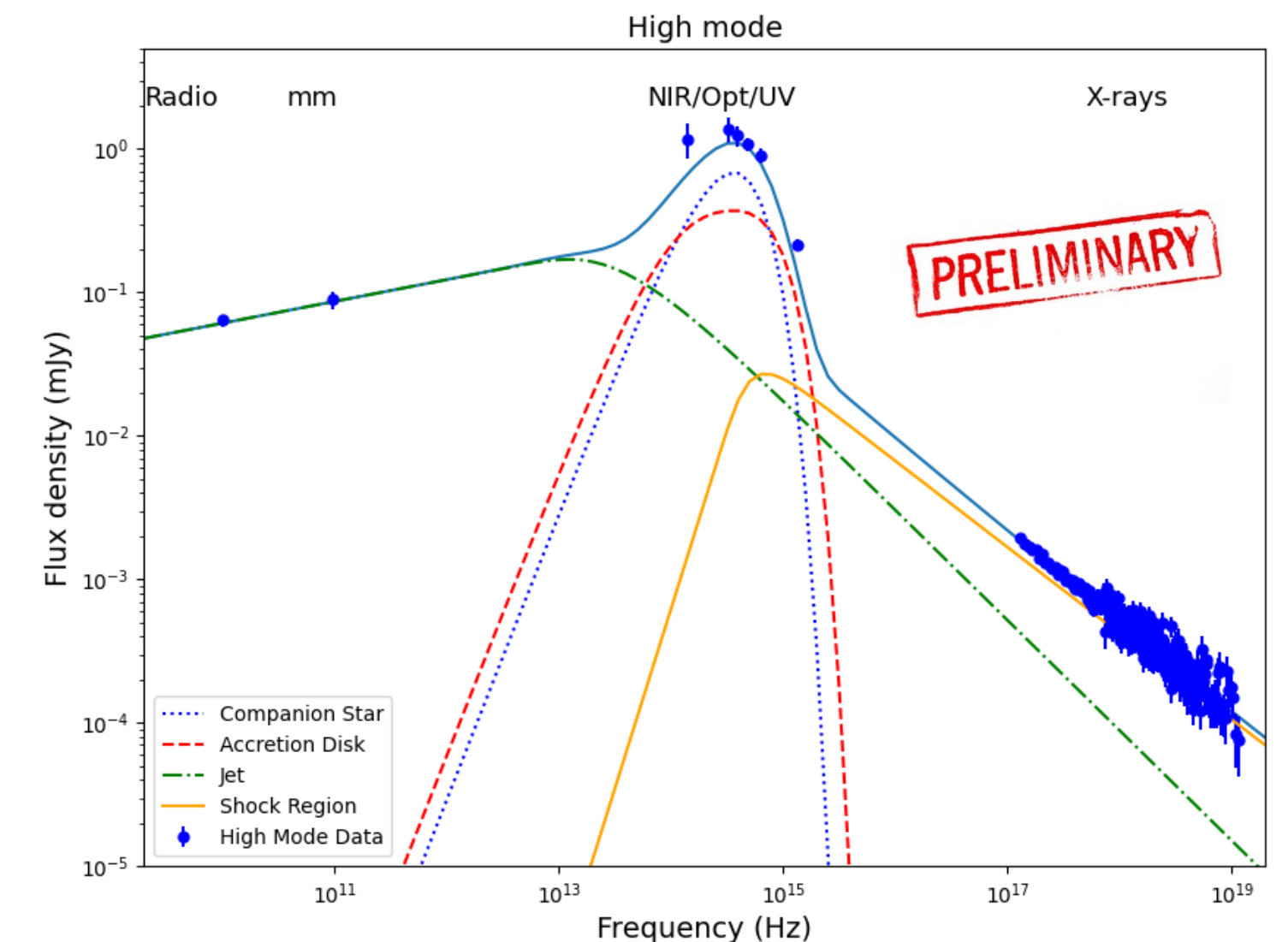
The jet would therefore be intrinsically polarized at 30%.

This would imply a highly ordered magnetic field at the base (~60%)

Prediction of X-ray LP due to the jet of ~12% in the IXPE band (in low mode) and 4% (in high mode): can be tested.



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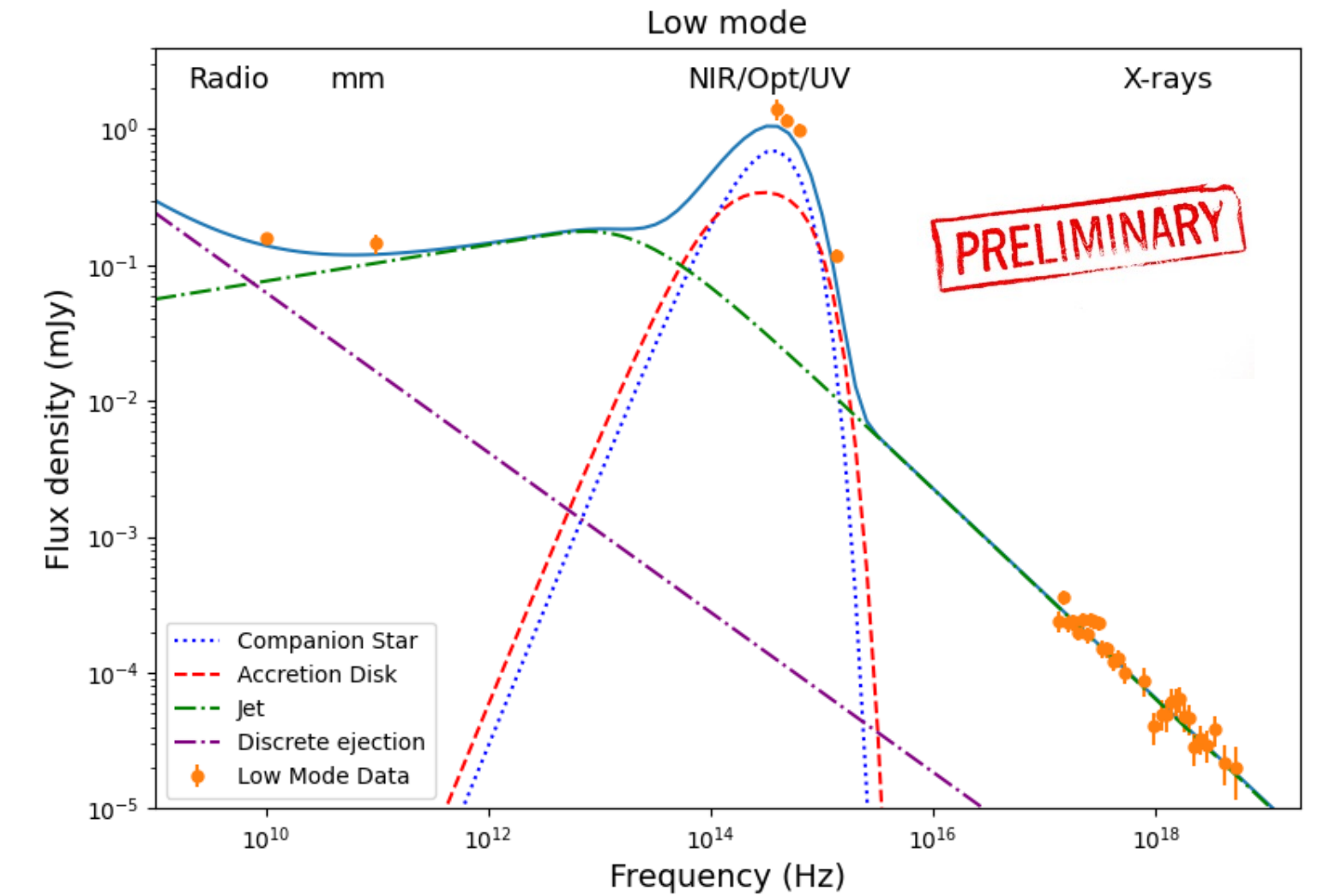
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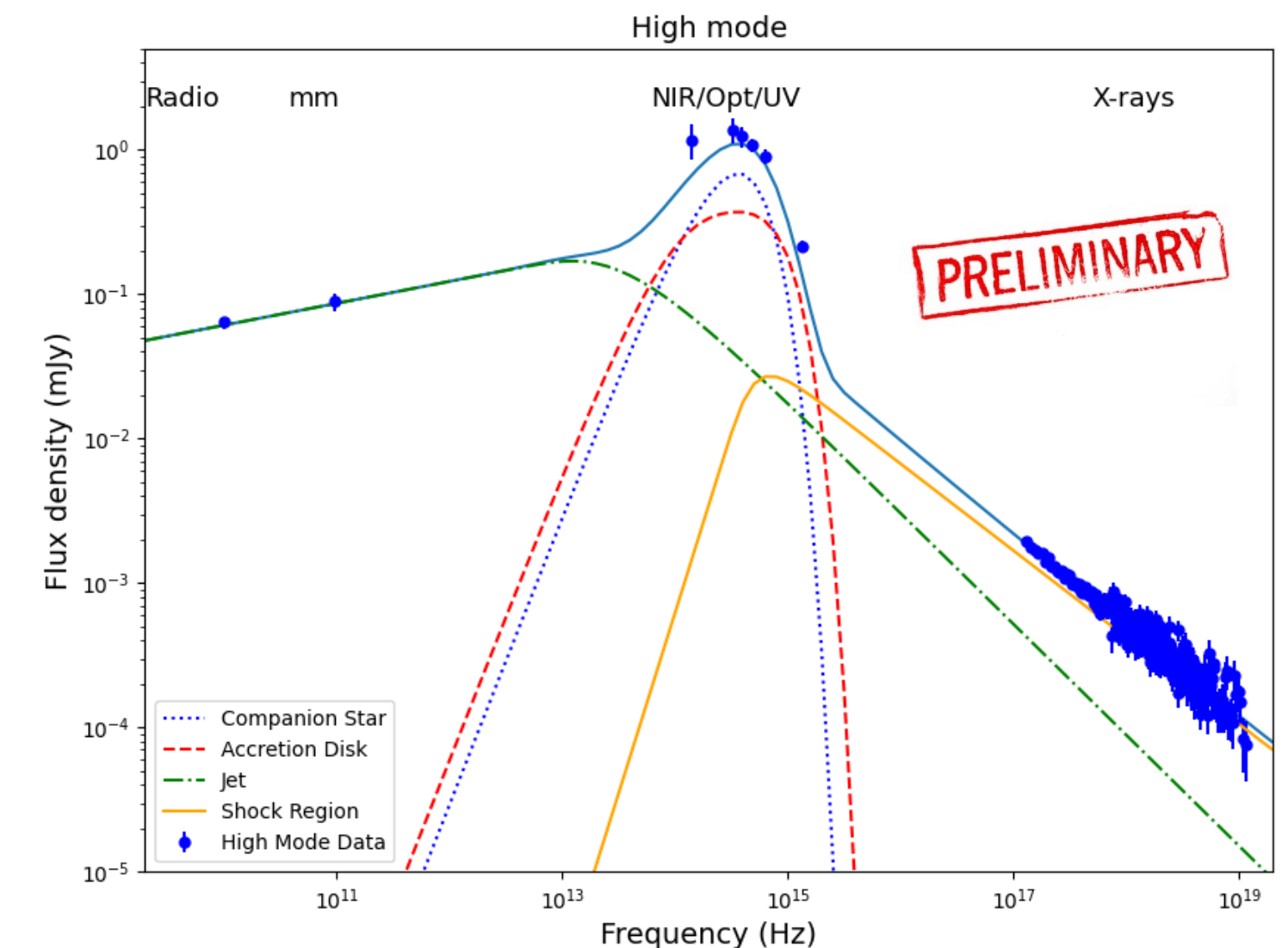
2 - Synchrotron in the region of shock

Scenario consistent with the ~lower P in low mode

$$P_{\text{low}} = (0.36^{+0.27}_{-0.35})\% \quad P_{\text{high}} = (0.65^{+0.43}_{-0.42})\%$$



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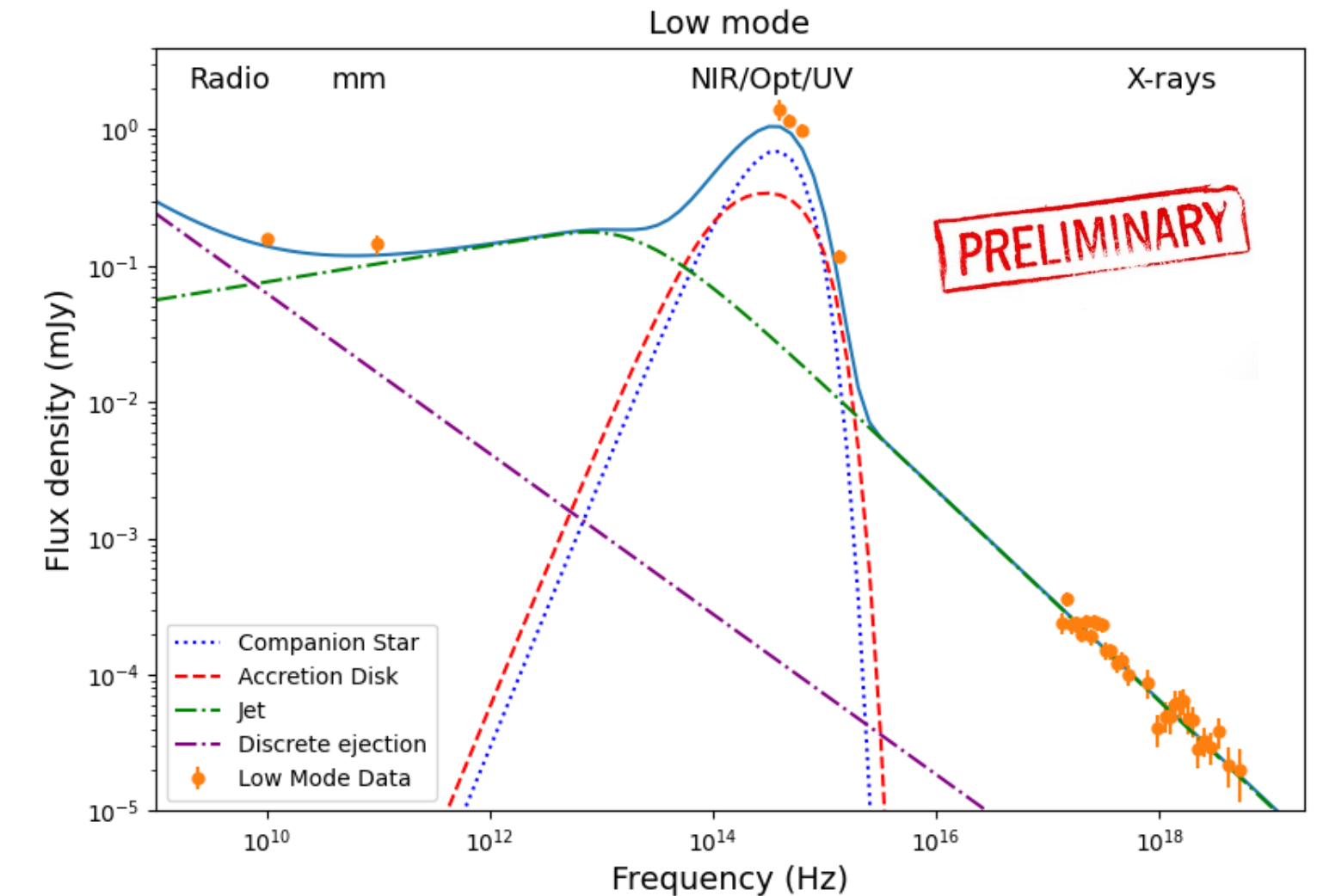
Shock contribution in r-band ~2.7%: intrinsic LP of ~23% in high mode.

If polarization is due to the impulse only (1% of total), then the pulse will be ~90% polarized!

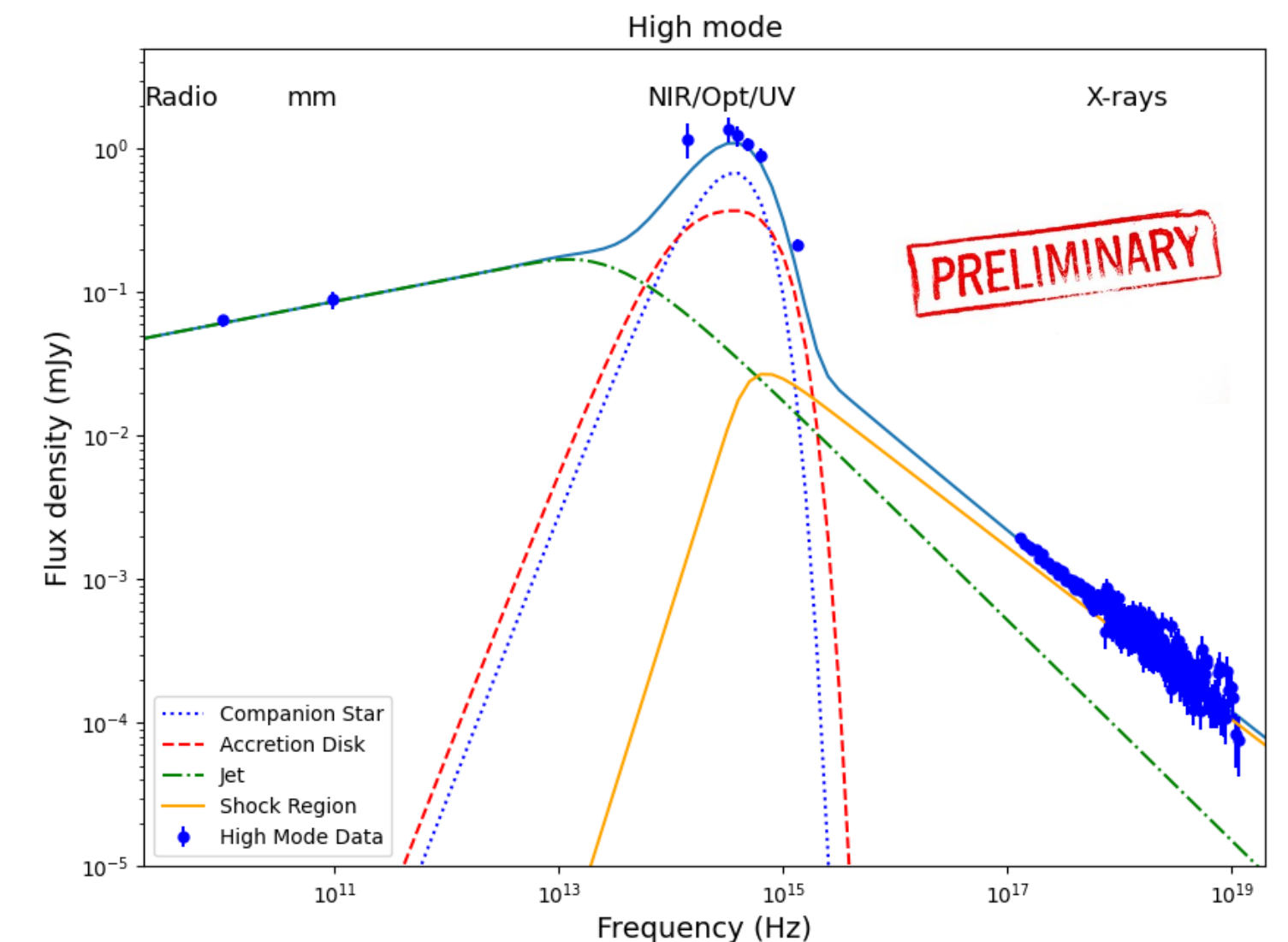
This can be tested with high time-resolution optical polarimetry.



Shock contribution of ~83% in X: X-ray pol of ~19% with IXPE.



Baglio, Coti Zelati et al. 2022 (in prep.)



Conclusions

The ultimate campaign on PSR J1023 performed in 2021 was extremely successful.

We put together a new scenario which can explain most of the phenomenology:

Radio/X-ray anti-correlation

Flares in the mm at the high/low mode switching

Mode switching in the X-rays

Optical - to - X-rays ms pulsations

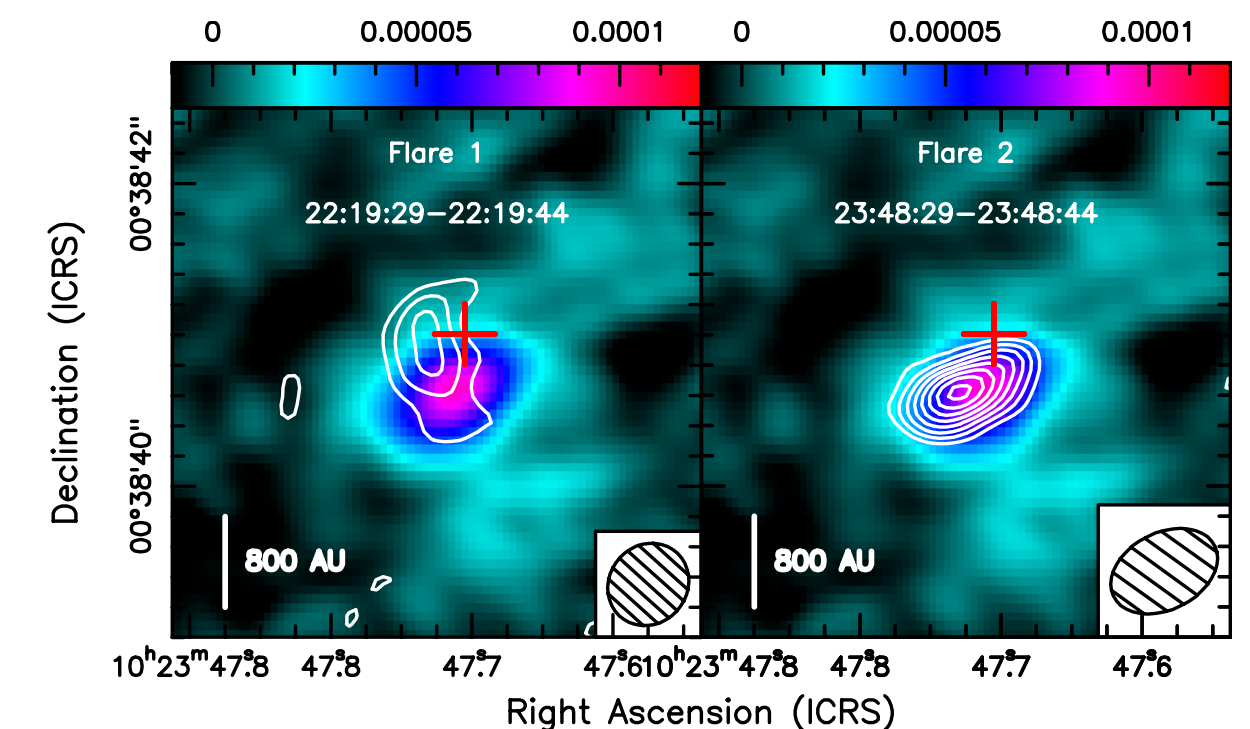
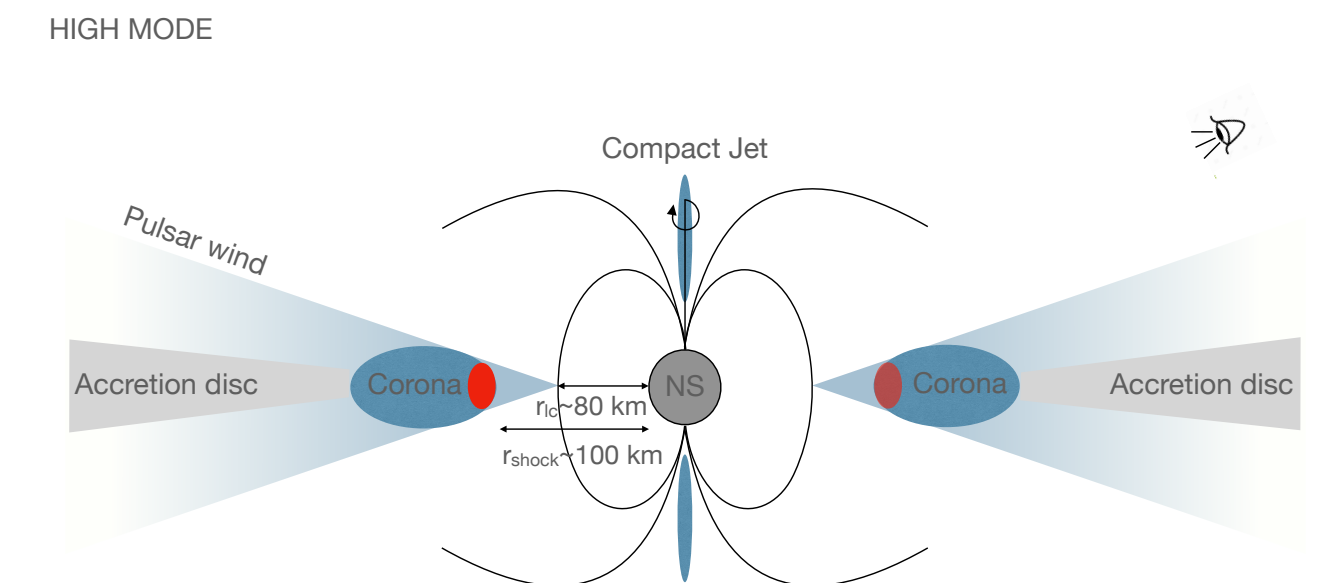
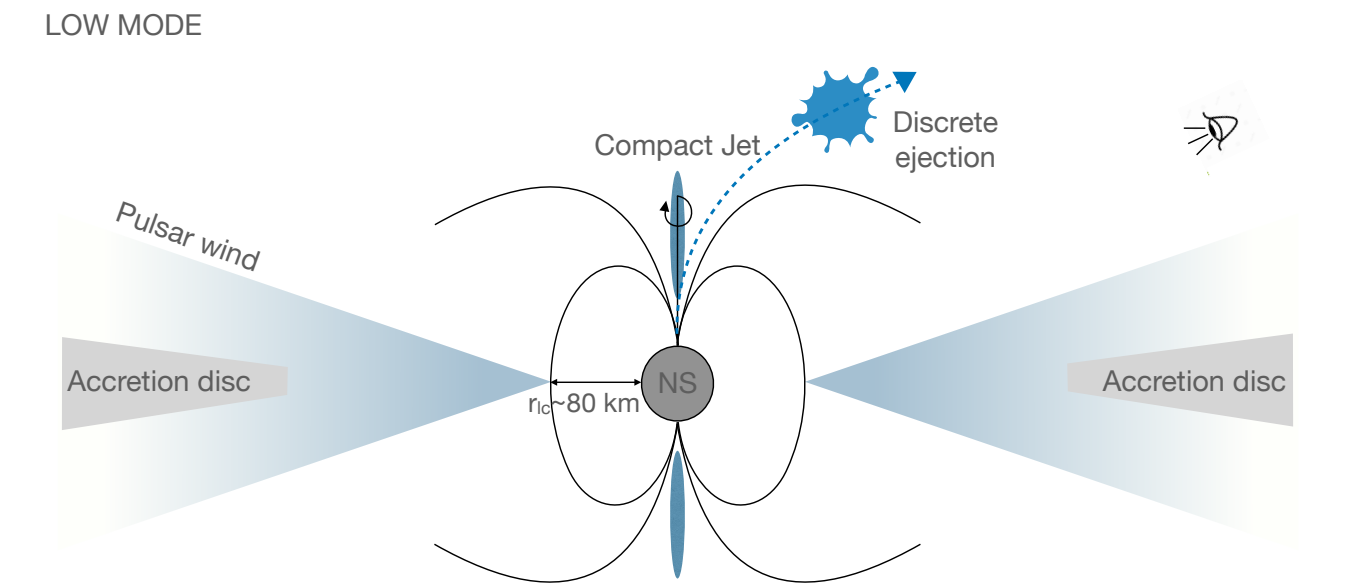
Polarization in the optical

We report on the first observations in the mm of a tMSP.

We explain why 1023 has an anomalous behavior on the radio/X-ray luminosity plane.

We could make predictions for X-ray polarization and high time-resolution optical polarimetry.

Future missions/instruments/campaign will be able to test the predictions and possibly confirm the scenario.



SPEAKERS

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Tata Institute of Fundamental Research

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European Southern Observatory

RACHEL SOMERVILLE
Flatiron Institute

SHERRY SUYU
*Max Planck Institute for Astrophysics
| Technical University of Munich*

TED VON HIPPEL
Embry-Riddle Aeronautical University

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SURVIVAL GUIDE
with JANNA LEVIN
*Barnard College of
Columbia University*

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