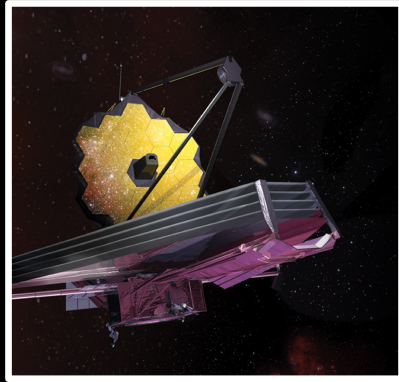


Probing the dynamic environment near black holes with Gemini and JWST



Alex Tetarenko

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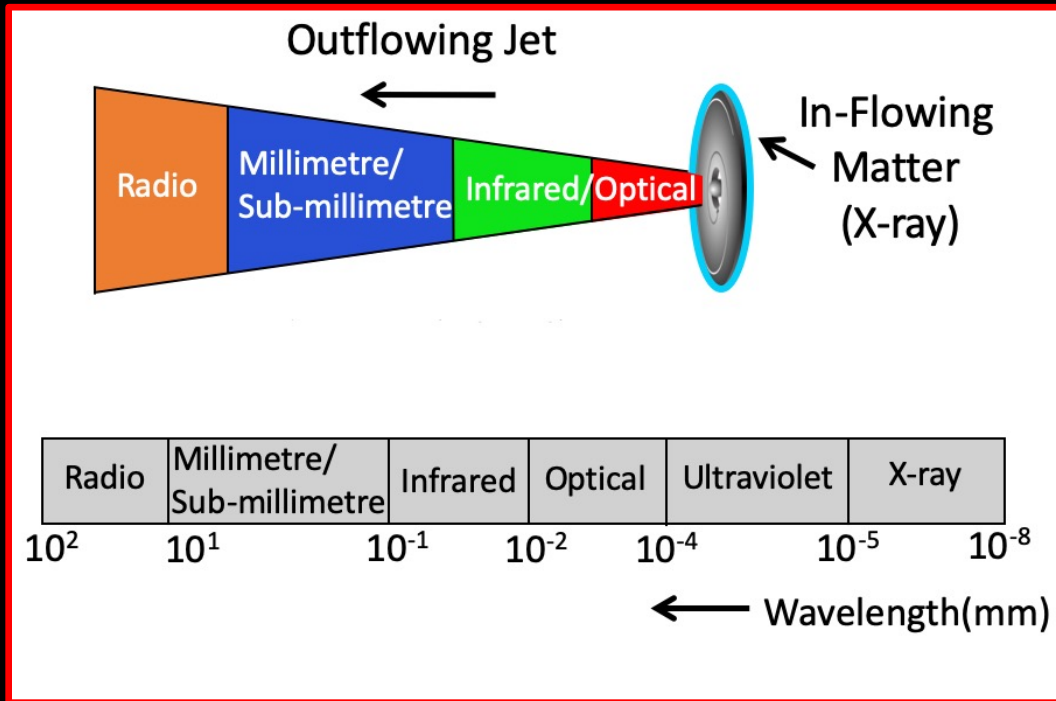


Eli Pattie, Tom Maccarone (Texas Tech),
Federico Vincentelli (IAC), and PG Casella (INAF)

With special thanks to Ricardo Salinas, Zach
Hartman, and Steve Howell



Black Hole X-ray Binaries



- Black hole accreting matter from a companion star
- Rapidly evolve through bright outburst periods on timescales of days to months
- Emit across the electromagnetic spectrum

Multi-wavelength Fast Timing of X-ray Binaries

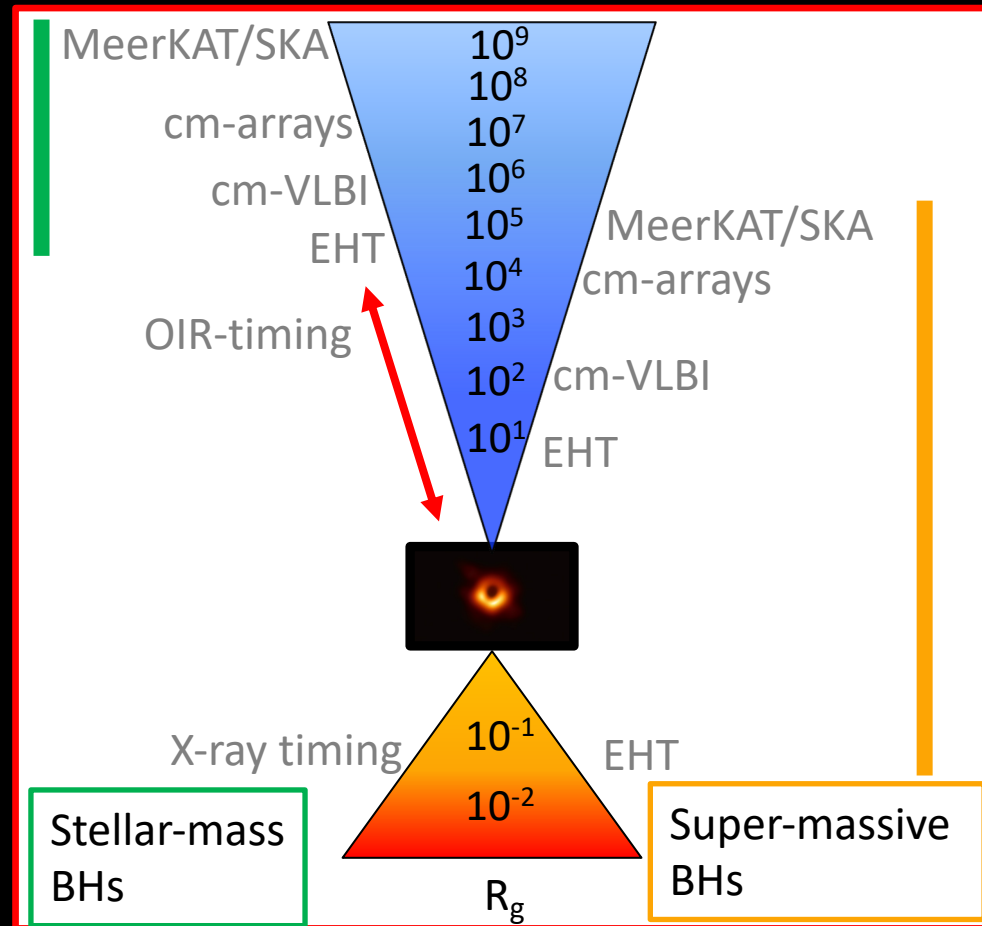


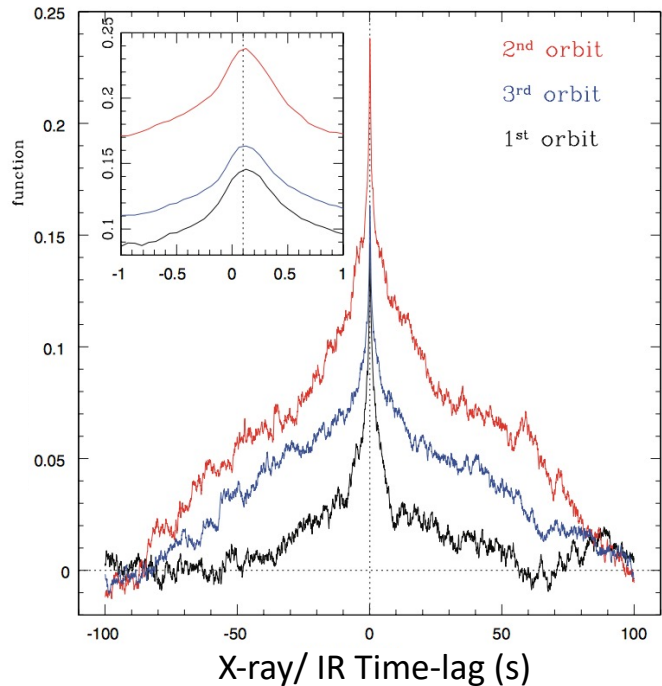
Image Credit:
Rob Fender



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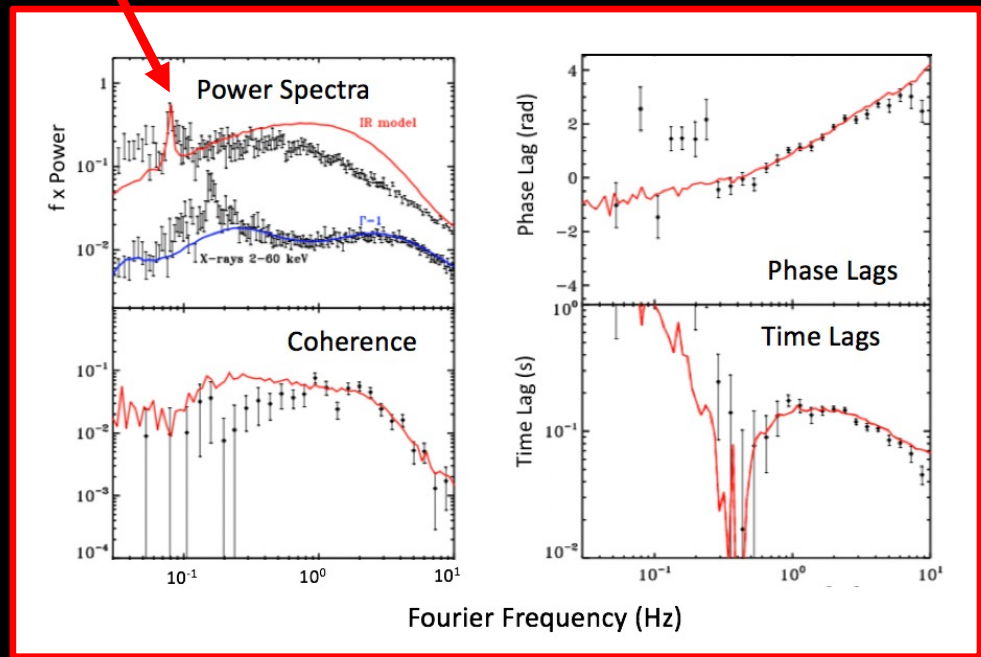
OIR Variability Studies in X-ray Binaries



Casella et al. 2010

Quasi-periodic Oscillation (QPO)

Ingram &
Motta 2019



Malzac et al. 2018

Timing Metrics Cheat Sheet

Power Spectra – Amplitude of variability on different timescales.

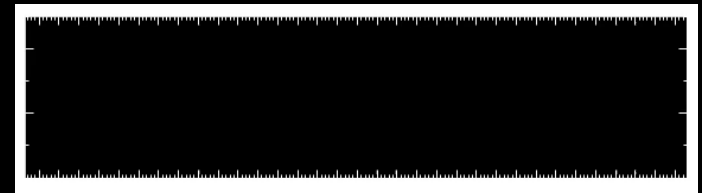
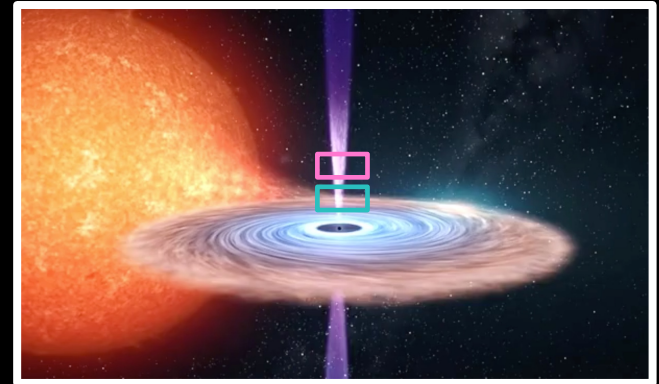
Lags – Delays between intensity fluctuations.

Coherence – How correlated are our signals?



Gemini's `Alopeke and Zorro

- Tens of ms time resolution in two simultaneous filters.
- 60 arcsec FOV in wide-field mode.
- `Alopeke on North, Zorro on South for full sky coverage.
- Rapid ToO response and coordination with multi-wavelength facilities.



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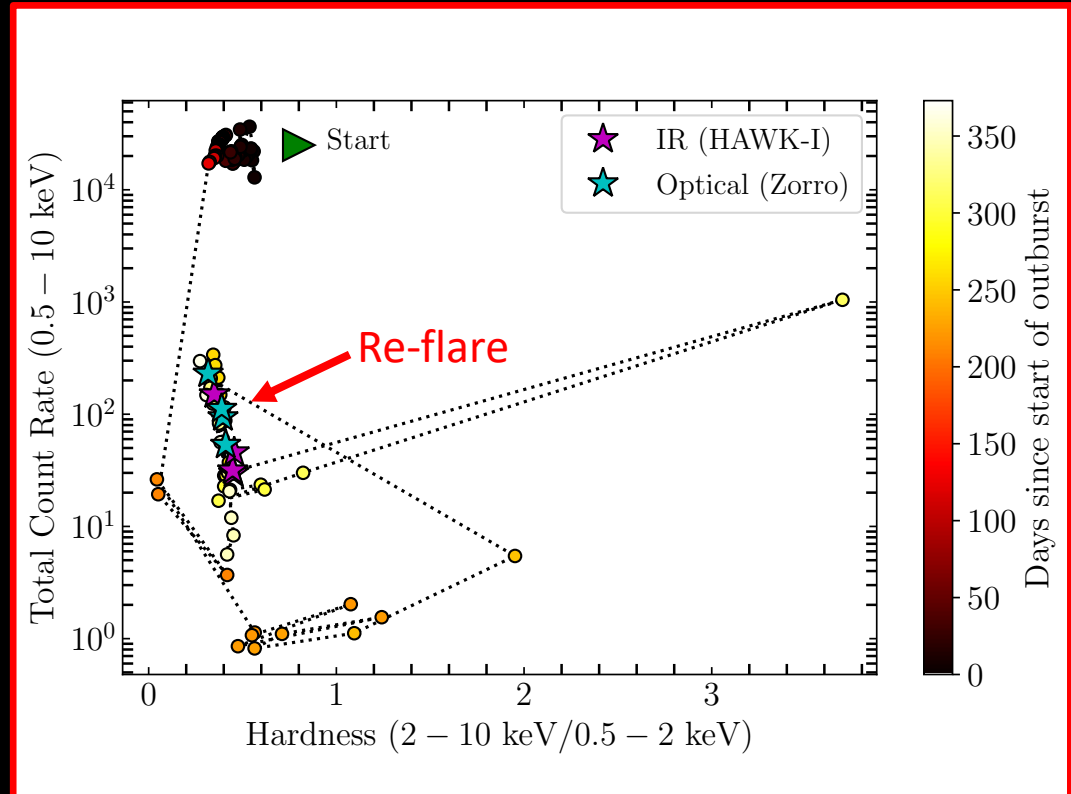
4U 1543-47



Eli Pattie

Timeline

- First outburst in 17 years detected in Jun 2021.
- Outburst fading in Jan 2022.
- Re-flare in Feb 2022.
- Our observations in March 2022.



Tetarenko et al., in prep

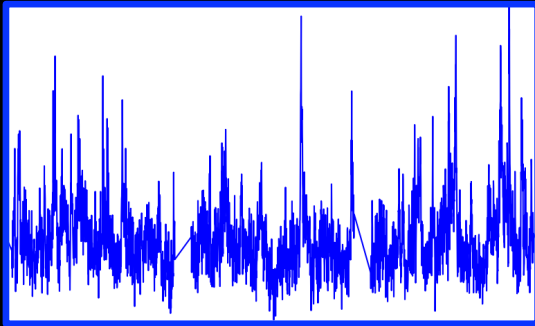


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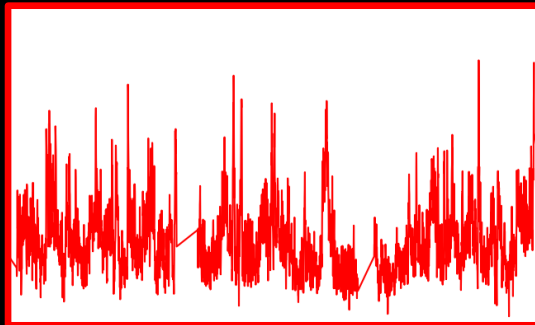


4U 1543-47 - Zorro

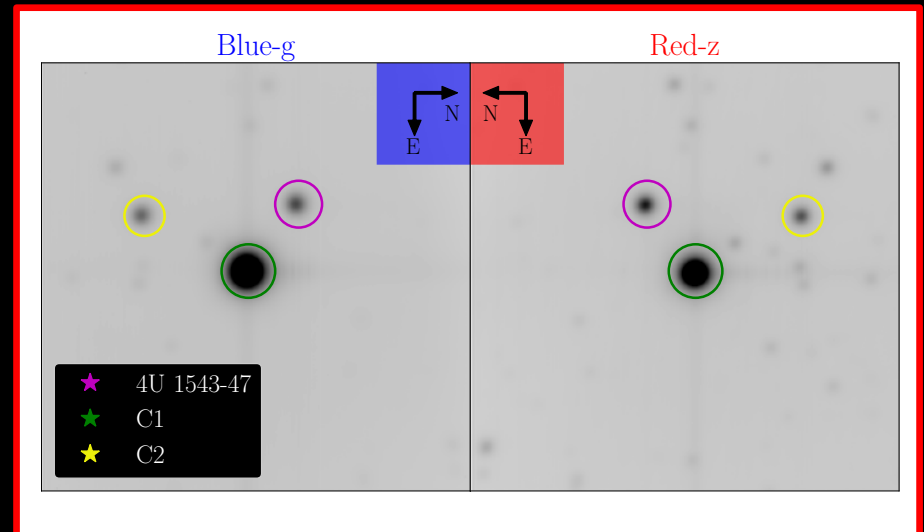
g-band (479 nm)



Rapid flaring clearly observed!



z-band (947 nm)

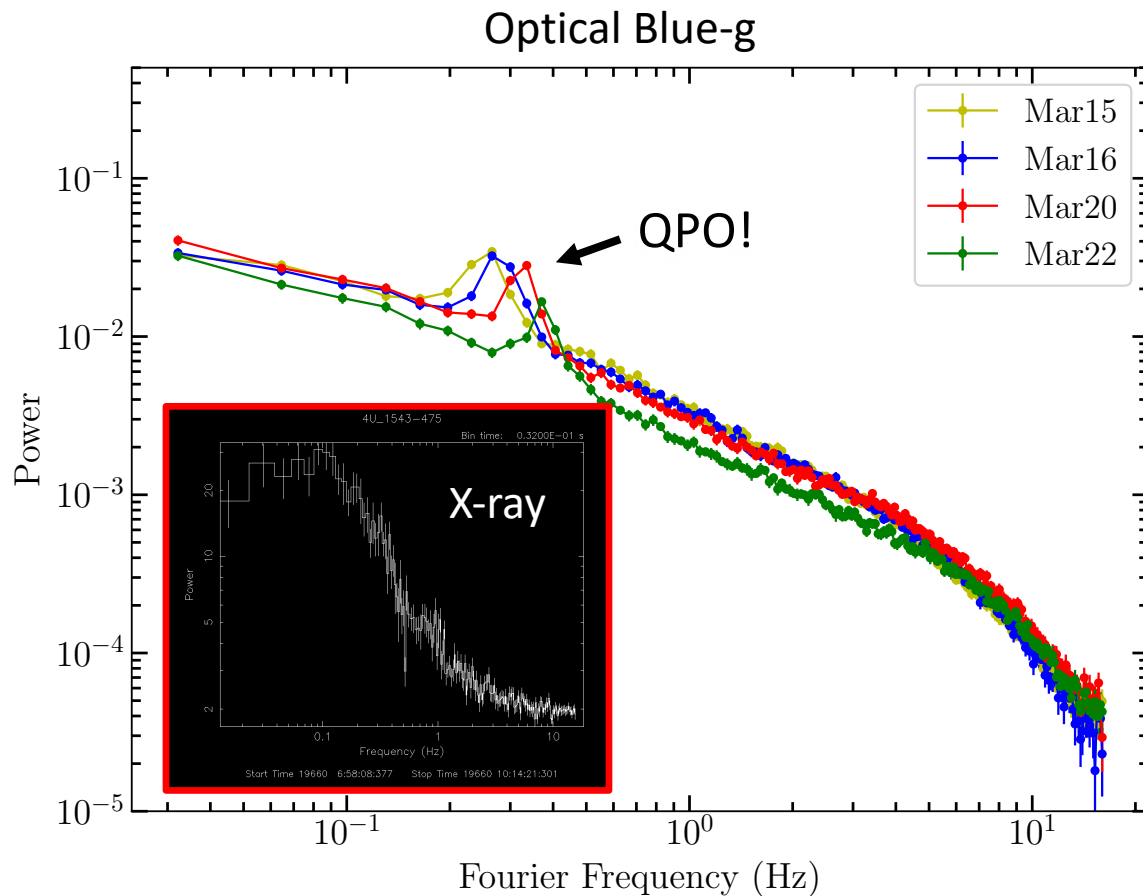


Tetarenko et al., in prep

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Fourier Power Spectra



- Evolving optical quasi-periodic oscillation (QPO)!
- Also see an IR QPO at frequencies \sim factor of 2 lower.
- No significant QPO feature in X-ray.

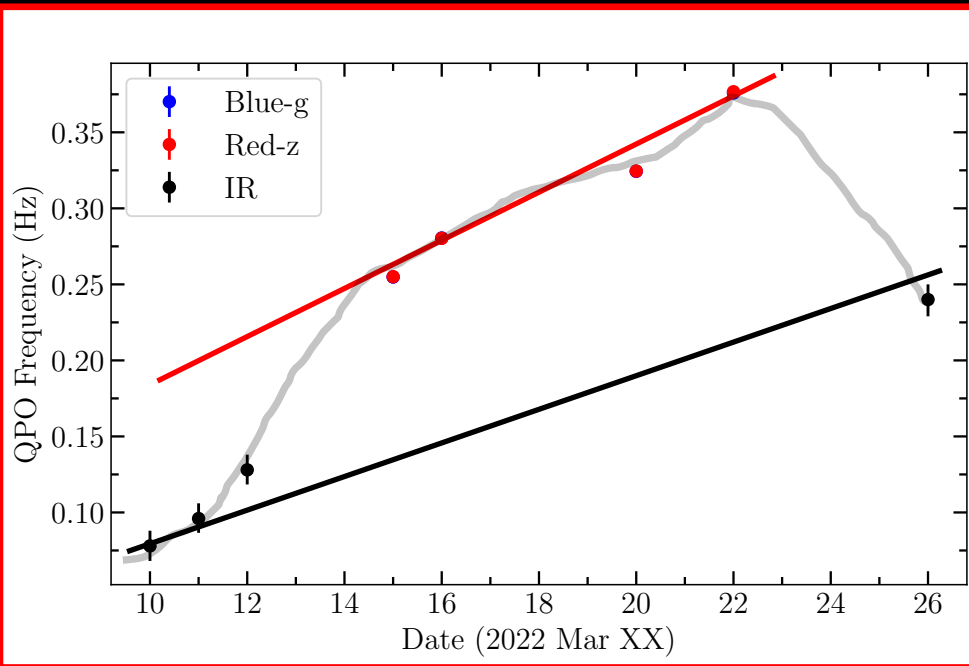


Tetarenko et al., in prep

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A closer look at the QPO



- Two scenarios for multi-band QPO:
 - Observing different harmonics in different bands.
 - QPO is evolving with time.

Tetarenko et al., in prep



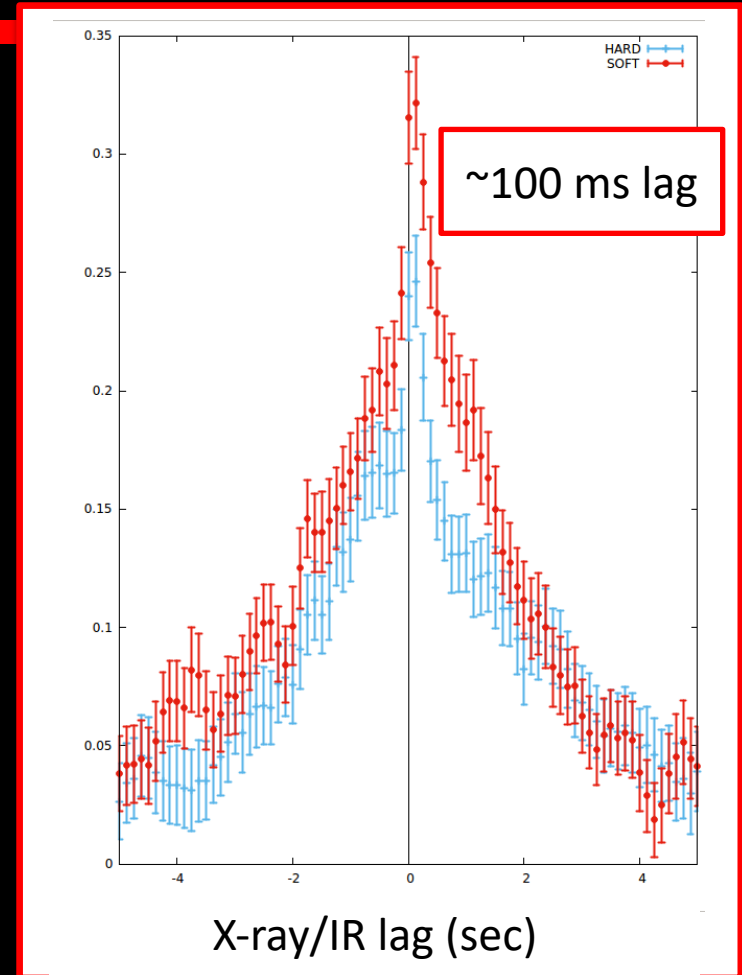
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How is the variability connected?

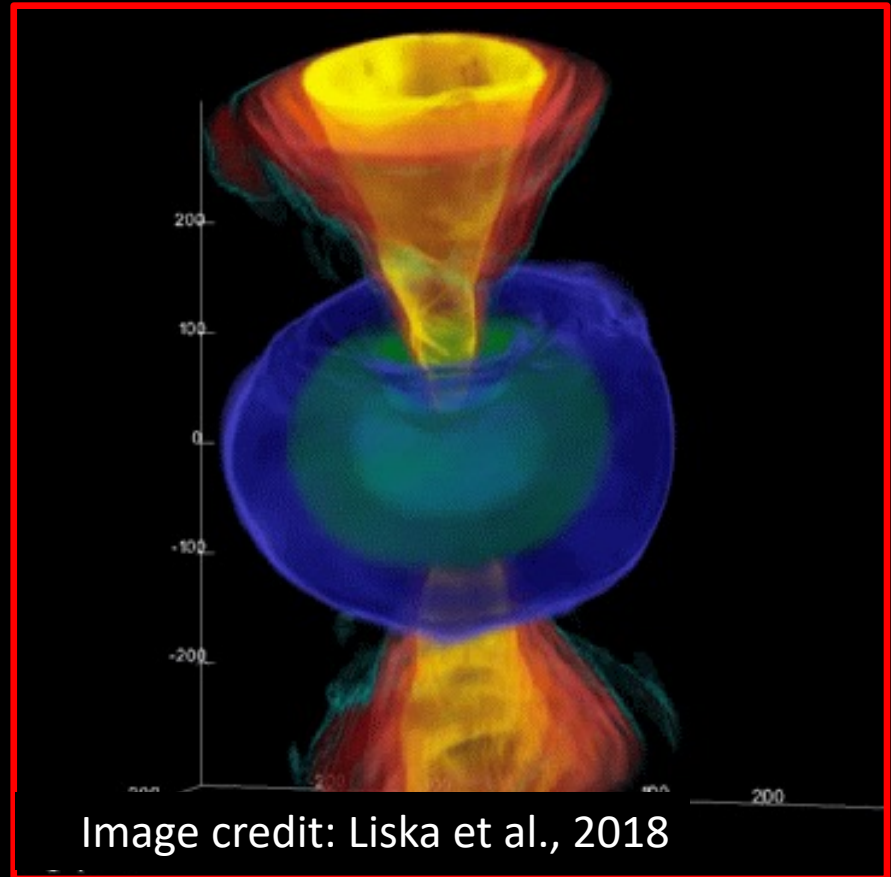
- Is the emission correlated?
 - Red and blue optical ✓
 - X-ray and IR ✓
 - X-ray and optical ✗

Vincentelli et al., in prep



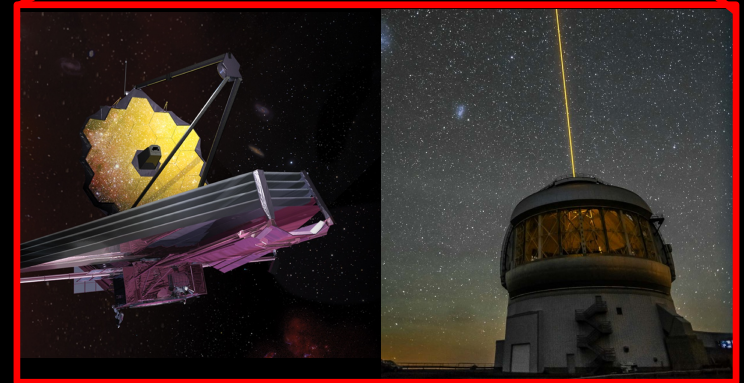
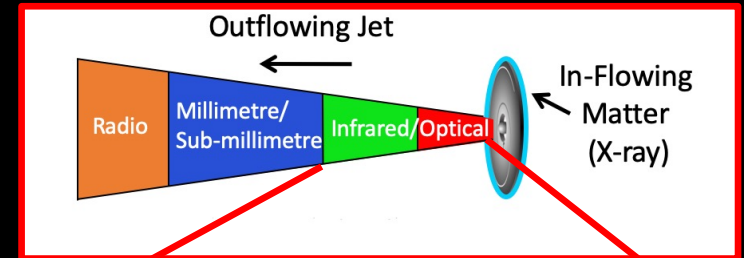
Conditions in the Jet/Accretion Flow

- Precessing jet and/or precessing inner accretion flow (e.g., Malzac et al. 2018, Veledina et al. 2013).
- Why no X-ray QPO?
 - Obscured accretion flow.
 - Low inclination source.
 - Low S/N.

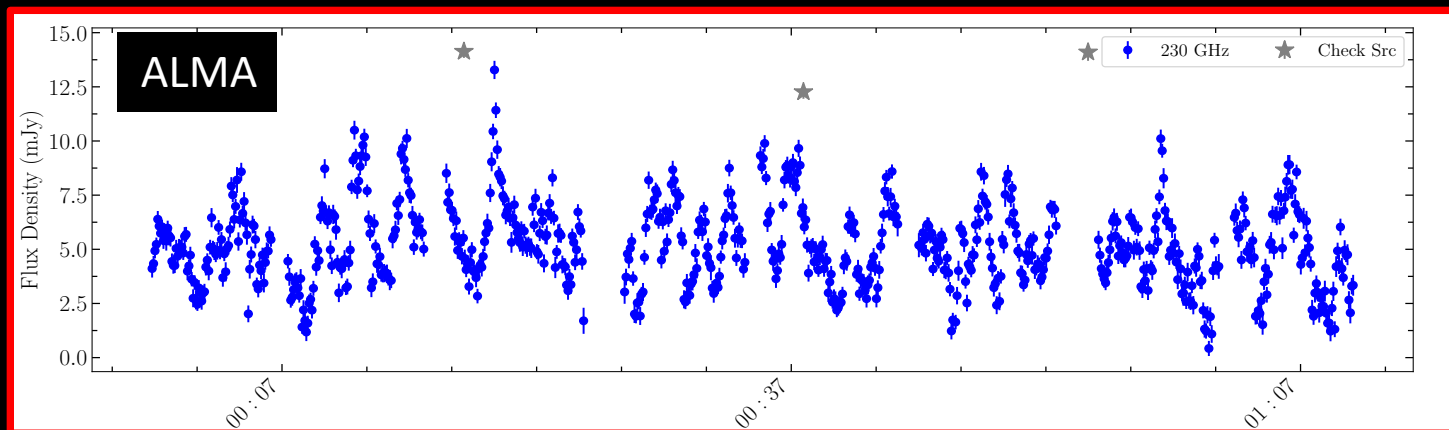
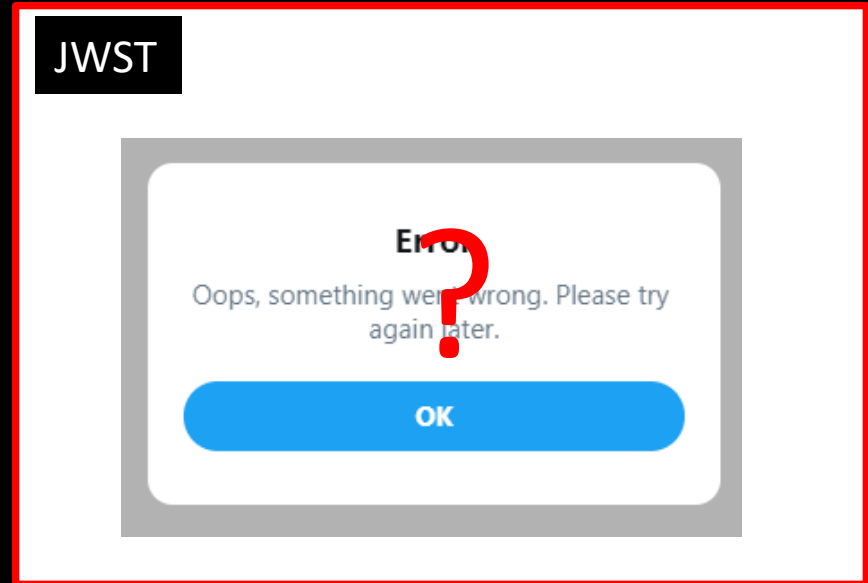
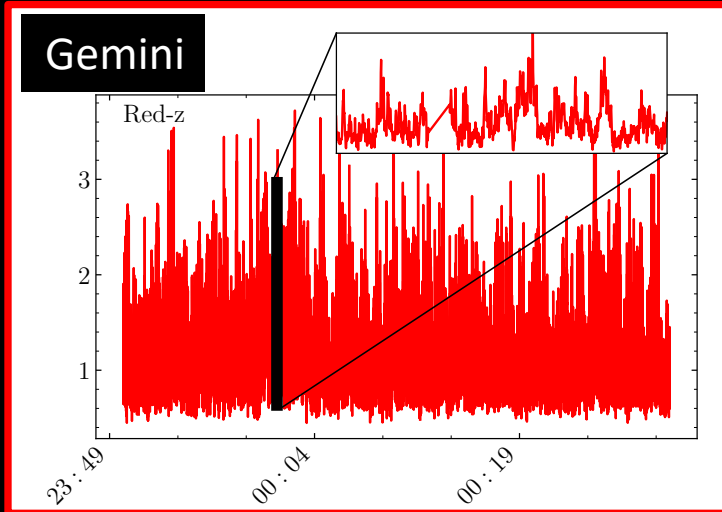


Synchronizing Gemini + JWST

- JWST provides rapid, continuous time-series over a broad mid-IR wavelength range (5-14 μm).
- High sensitivity (factor of 20 improvement over WISE).
- Highly constraining for different models of time variability (jet plasma shocks vs hot inner accretion flow).



The JWST/Gemini/ALMA campaign that never was...



Summary

- Multi-wavelength spectral-timing is an incredibly powerful tool for unlocking complicated jet and accretion physics.
- We need a suite of fast timing capable facilities to take full advantage of the time-domain.
- Gemini's `Alopeke/Zorro + JWST offers exciting new options in the optical/infrared regimes.

Thank you!



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