




# Unveiling Supermassive Black Hole Environments with Tidal Disruption Events




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June 29, 2023

*The Restless Nature of AGN*



Galaxy WISEA J003113.52+850031.8 as  
imaged by PAN-STARRS in *gri* color

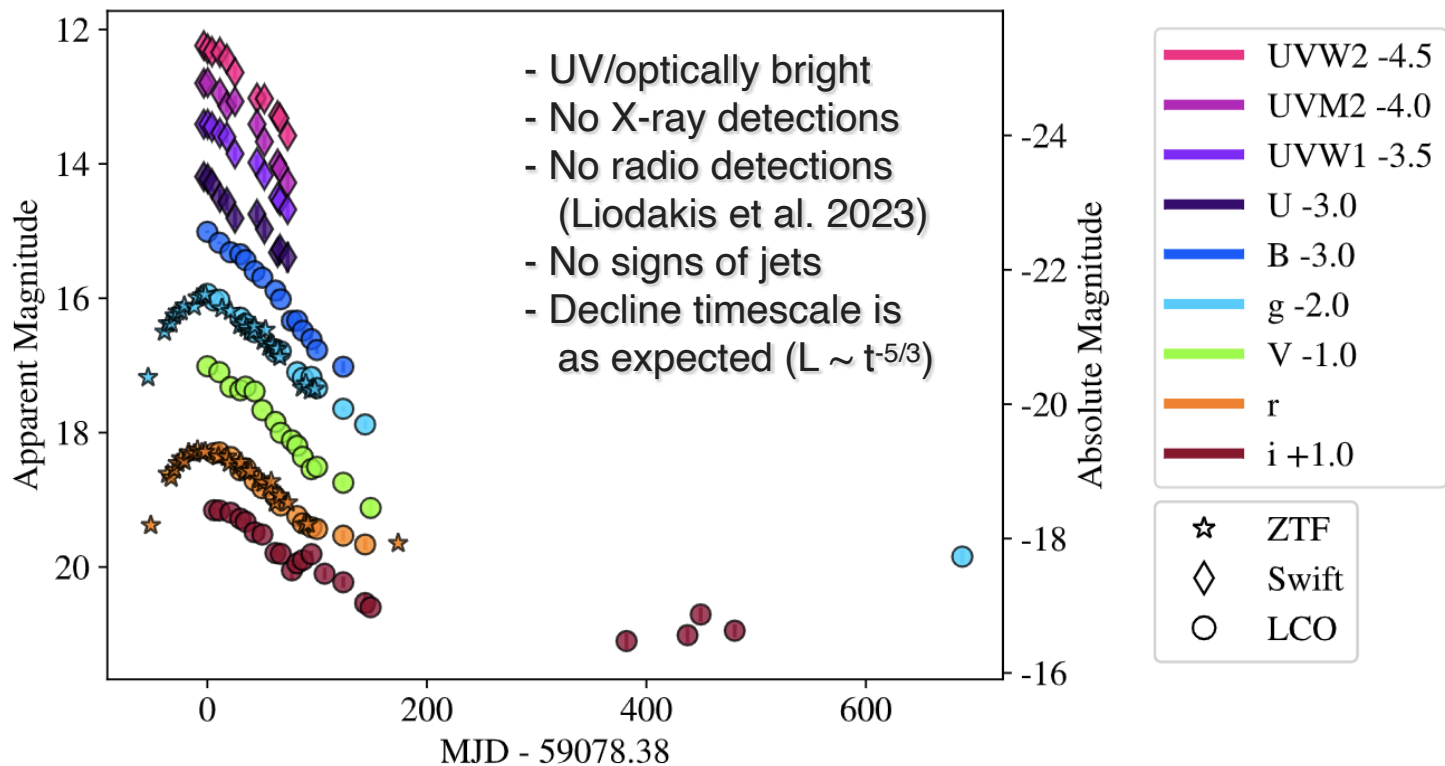


Galaxy WISEA J003113.52+850031.8 as  
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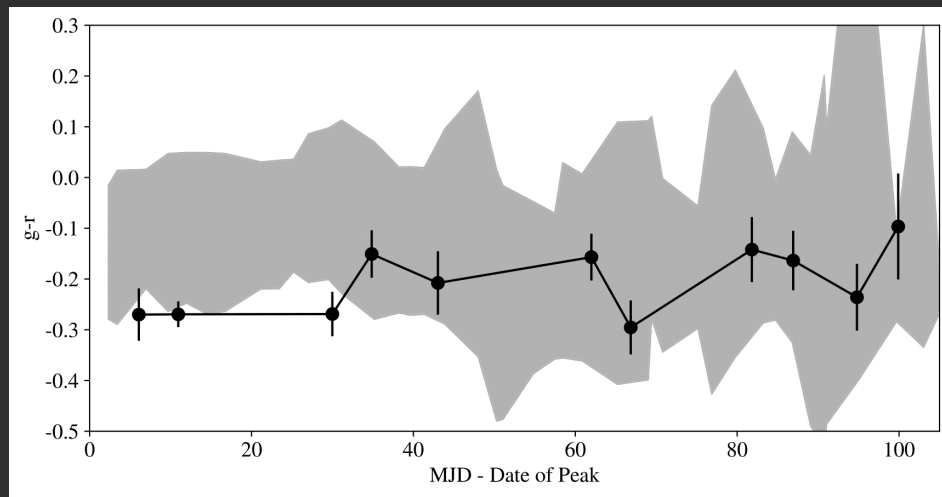
# AT 2020mot: A “normal” optical TDE...



. . . no TDE like it

Las Cumbres is the only telescope contributing i-band photometry for AT 2020mot

AT 2020mot generally agrees with the broader sample of TDEs in  $g-r$  color

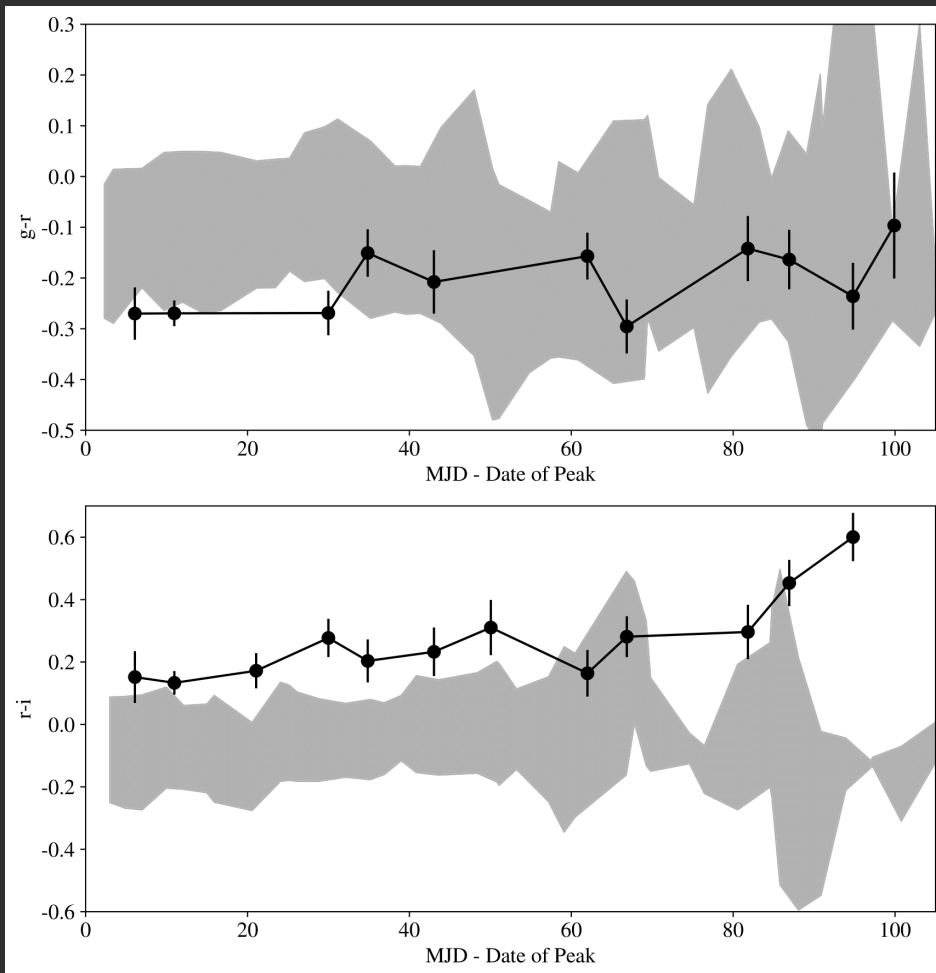


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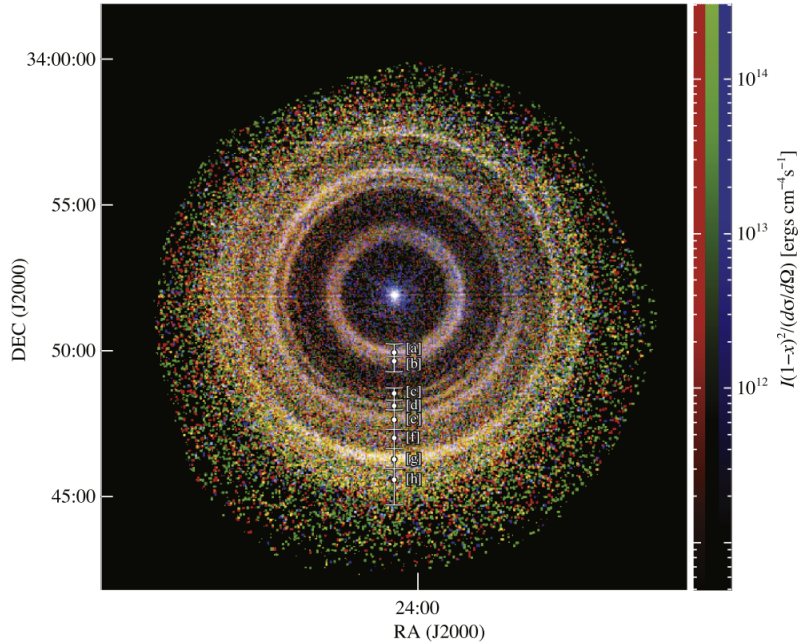
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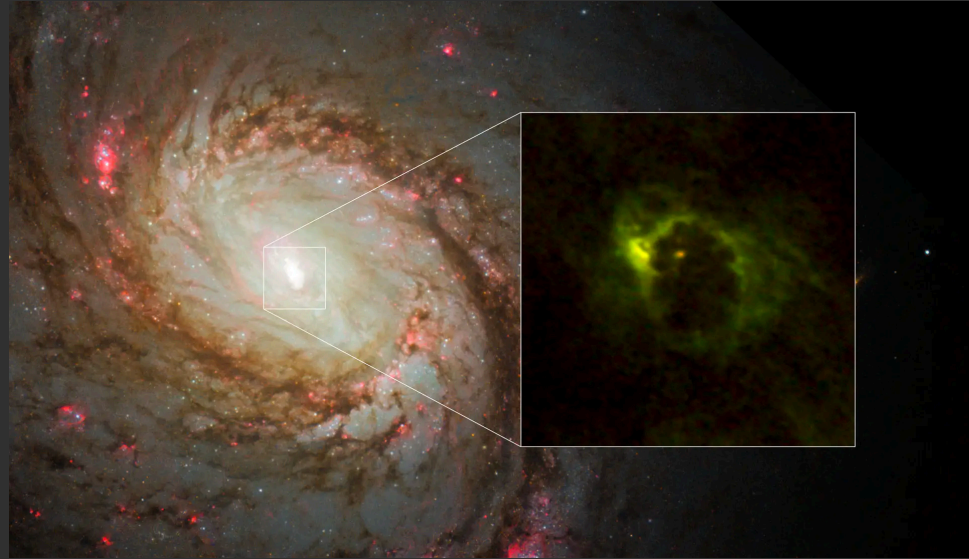
But in *r-i*, 2020mot diverges from the norm from the start!



# How is dust arranged near BHs?



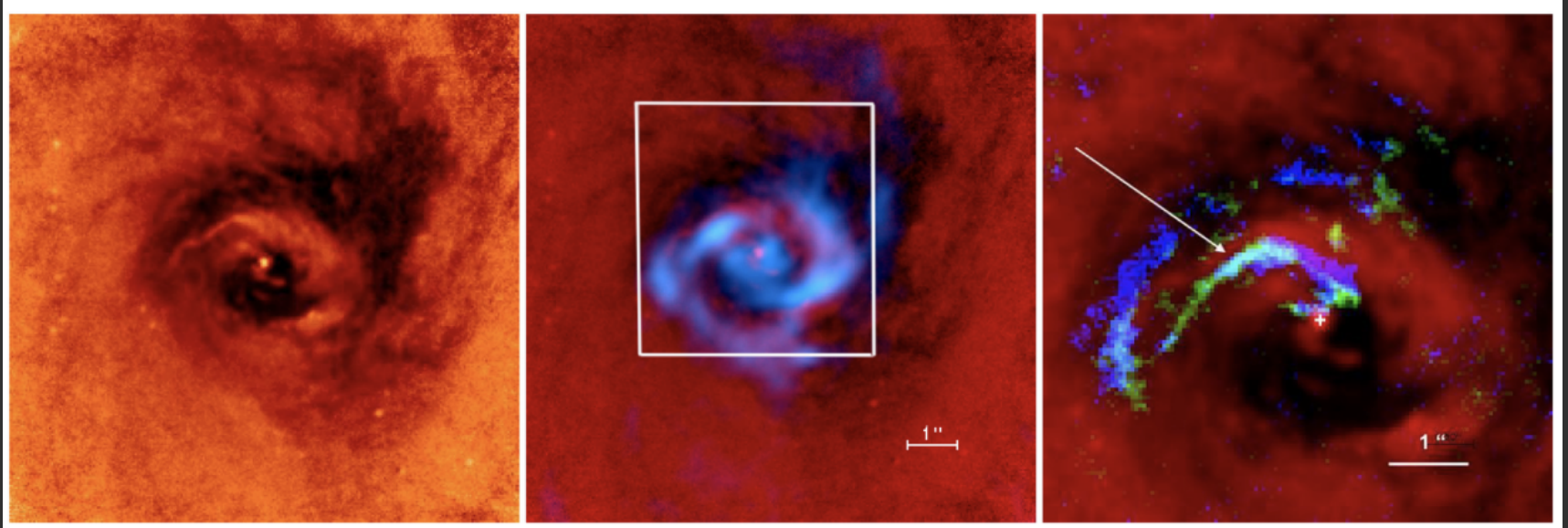
**Figure 4.** Three-color stacked exposure-corrected *Swift* XRT image of the 2015 V404 Cyg light echo in the 0.5–1, 1–2, and 2–3 keV bands (red, green, and blue, respectively). All 50 *Swift* observations listed in Table 1 were



Dusty + molecular torus around SMBH found from narrowband imaging of HCN and HCO+ (Imanishi et al. 2018)

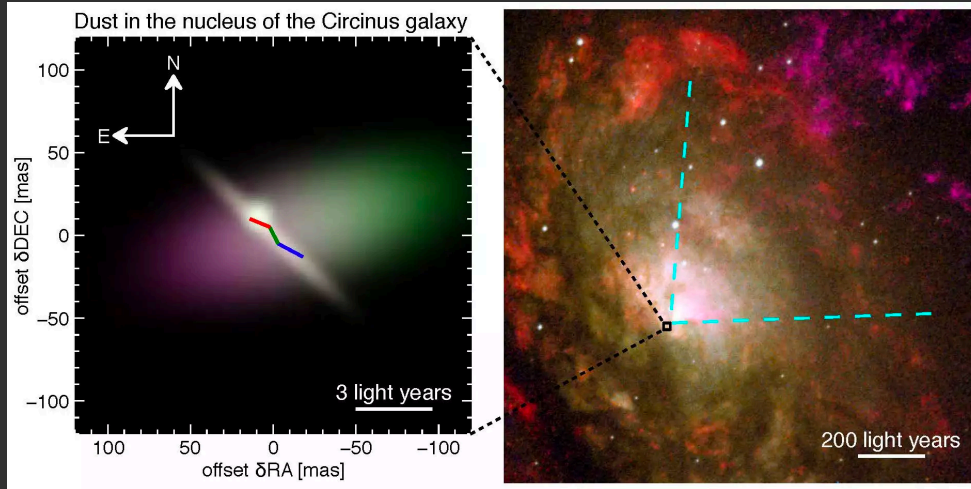


# How is dust arranged near BHs?



Filamentary dust lanes around SMBH (Prieto et al. 2021)

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Inner dust disk (<1pc) and larger dusty torus (1-5pc) around the SMBH of Circinus (Tristram et al. 2013)

Dusty tori can be inferred within the inner 10pc of SMBH via infrared imaging  
 But, reverberation mapping gets us closer:

AGN Host	Inner radius	Source
NGC 4051, NGC 3227	0.01pc	Suganuma 2006
NGC 6418	0.03pc	Vasquez 2015
NGC 5548, NGC4151	0.04pc	Suganuma 2006, Minezaki 2004
NGC 7469, WPVS48	0.06pc	Suganuma 2006, Nuñez 2014
3C390.3	0.08pc	Twadelle 2012

# How are TDE environments different?

1. TDEs can occur in quiescent galaxies, contrasting with AGN samples
2. Weak echoes indicate a dust covering factor of  $f_c \sim 0.01$  (AGN have  $0.1 < f_c < 1$ )
3. Torus geometry of dust unlikely; thin/flat disks and rings favored

TDE	Inner radius	Sources
PS1-10adi AT 2019avd ASASSN-18zj PS18kh	$\sim 0.01$ pc	Wang 2023 Jiang 2019
ASASSN-14li ASASSN-18ul ZTF18acaqdaa	0.08 - 0.09pc	Jiang 2019
PTF-09axc	0.12pc	van Velzen 2016
AT 2017gge	0.14pc	Wang 2022
PTF-09ge	0.15pc	van Velzen 2016
iPTF16fnl ASASSN-15lh ASASSN-15oi	$> 0.25$ pc	Jiang 2019

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4. TDE host galaxies are typically post-starburst; how does the heating of nuclear dust impact star formation rates?

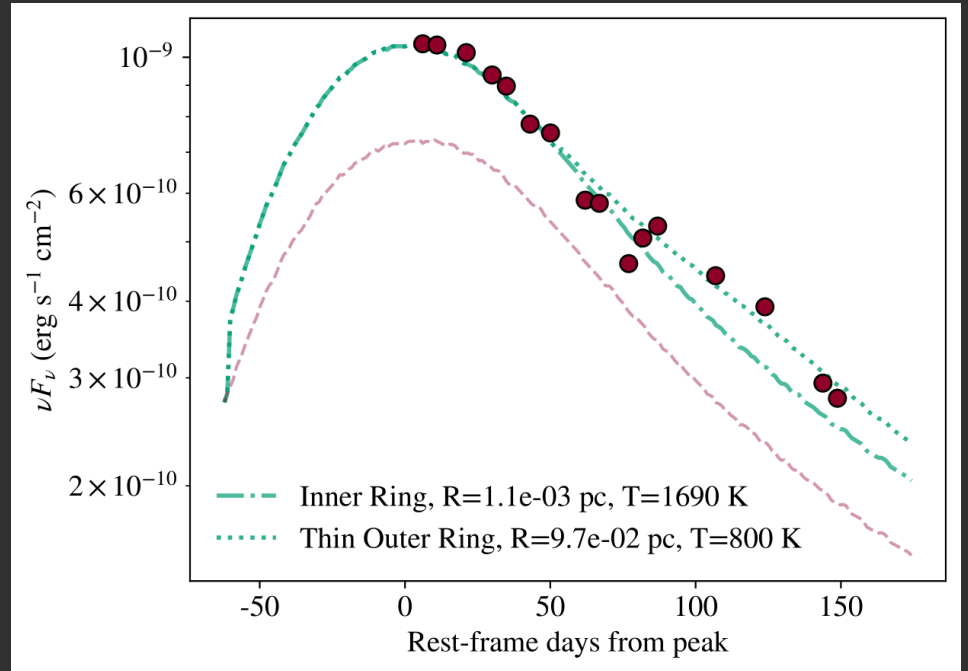
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# How does AT 2020mot compare?

If the early IR excess is from dust, that dust is inferred at a distance of **0.001 parsecs** from the SMBH, the **smallest scale yet uncovered!**

TDE	Innermost radius
AT 2020mot	0.001pc!
All other TDEs with dust echoes	>0.01pc

The “bump” is also well explained by a ring of dust at 0.09pc from the SMBH - **concentric rings?**



# What does this mean?

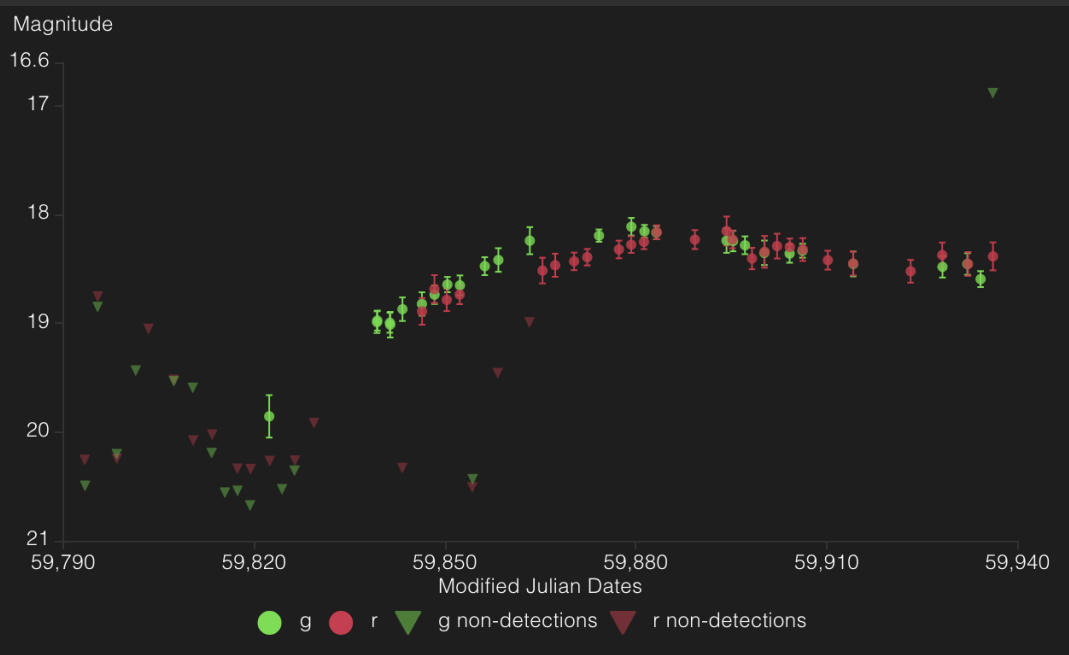
Does black hole mass correlate with any circumnuclear dust properties?

E.g. dust grain properties, thickness and geometry

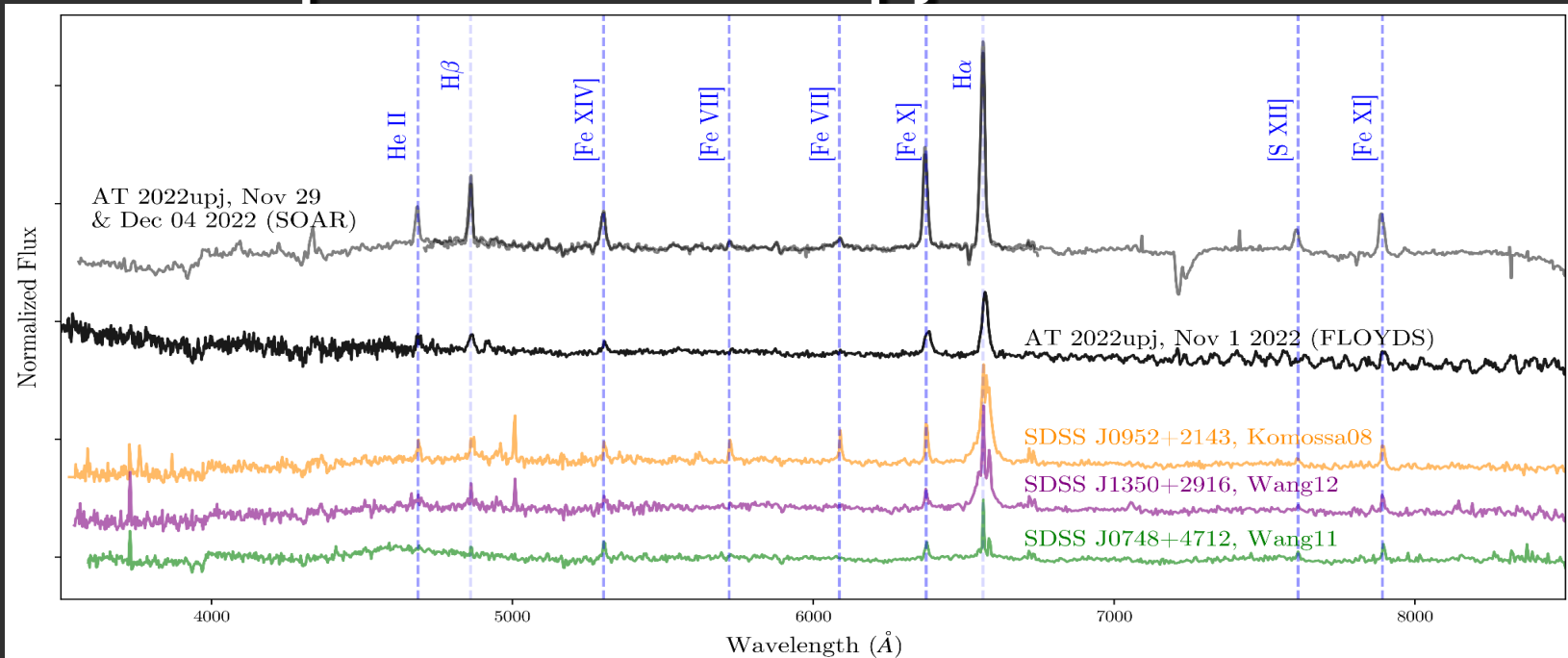
Preliminary results show little correlation, but errors from other studies are very high from sparse IR sampling

Inner radius	BH mass
<i>0.001pc</i>	<b>3e6</b>
~0.01pc	6e6 1.38e6 2.69e6
0.08 - 0.09pc	1.69e6 1.0e7 1.58e7
0.12pc	2.69e6
0.14pc	4.68e6
0.15pc	5.65e6
>0.25pc	3.16e5 5.2e8 3.98e6

# What's up next? 2022upj!



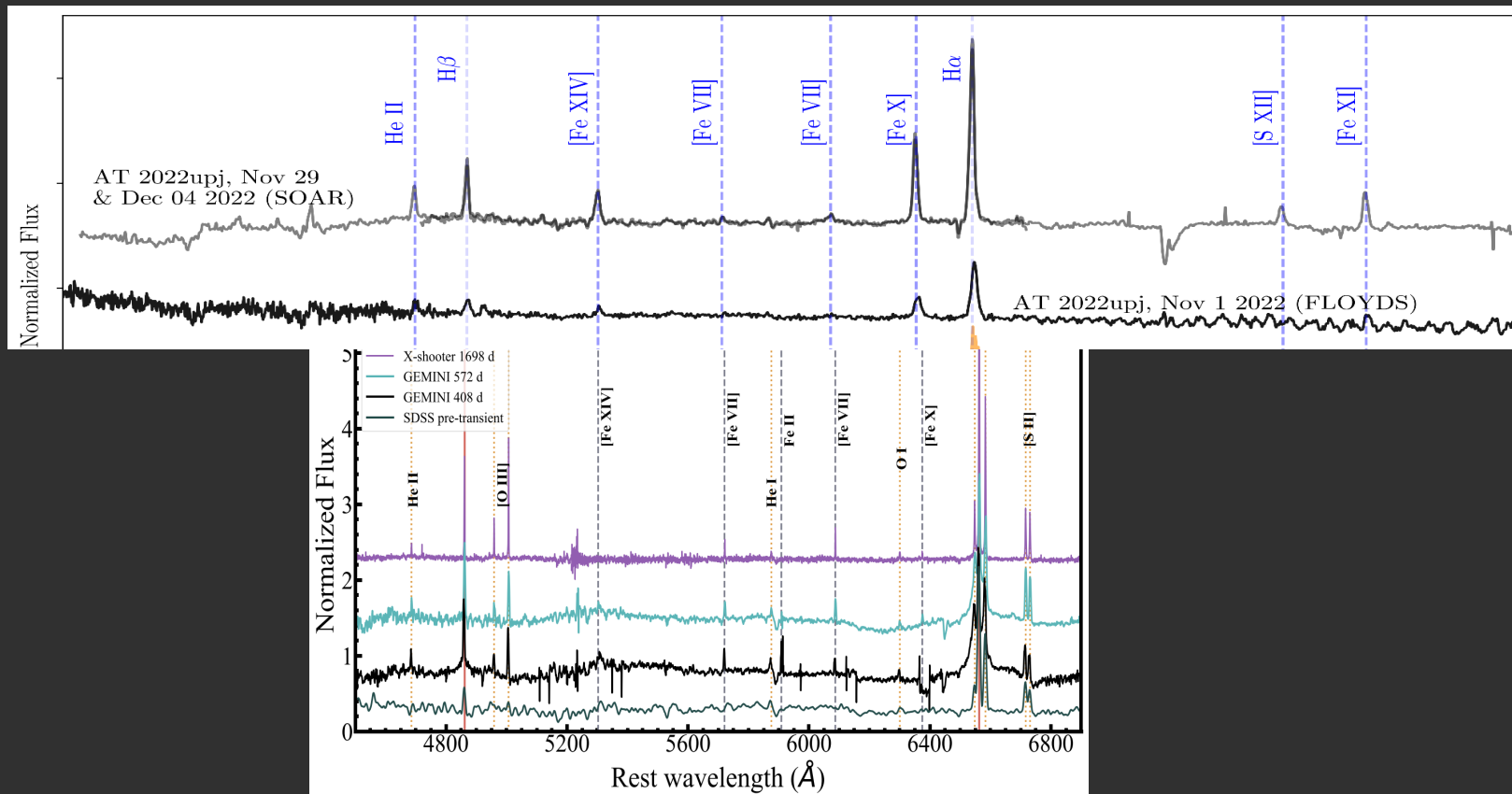
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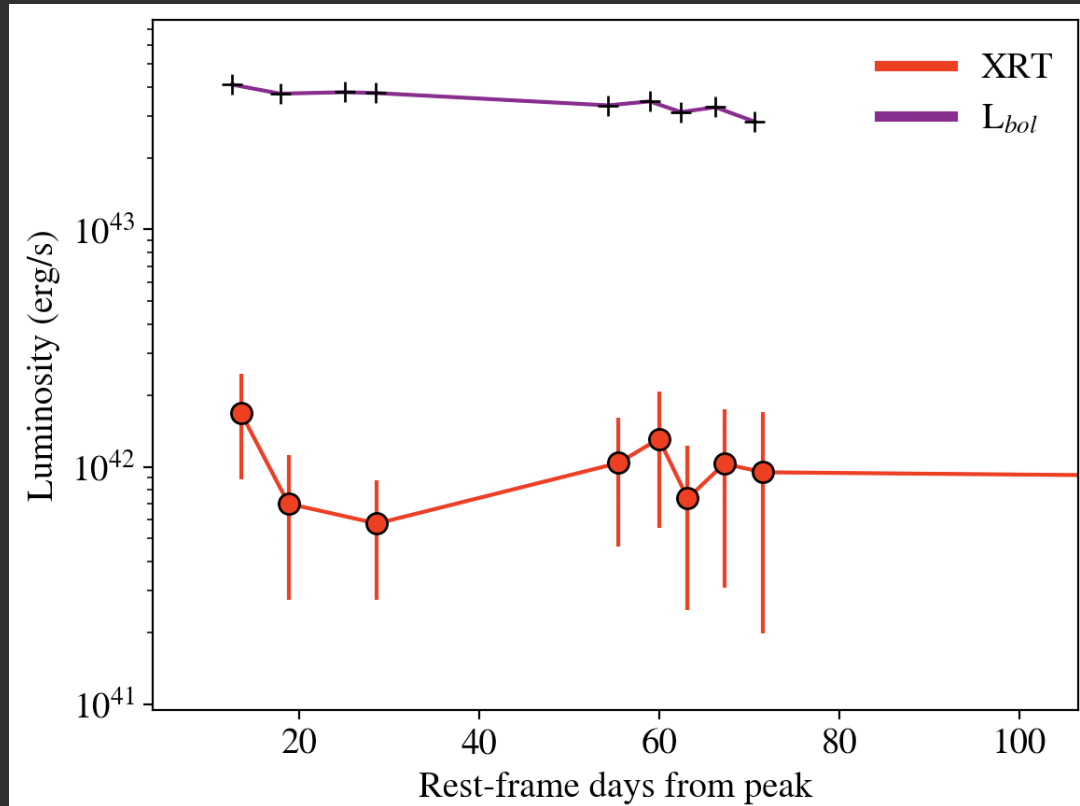
**Figure 2.** A blue continuum with He II 4686 $\text{\AA}$ , H $\alpha$ , and H $\beta$  emission lines; strong and narrow high-ionization emission lines [Fe X] and [Fe XIV]; and a lack of [Fe VII] and [O III] lines all define the subset of ECLEs that were designated as TDEs in Wang et al. (2011, 2012).



# Comparison with AT 2017gge

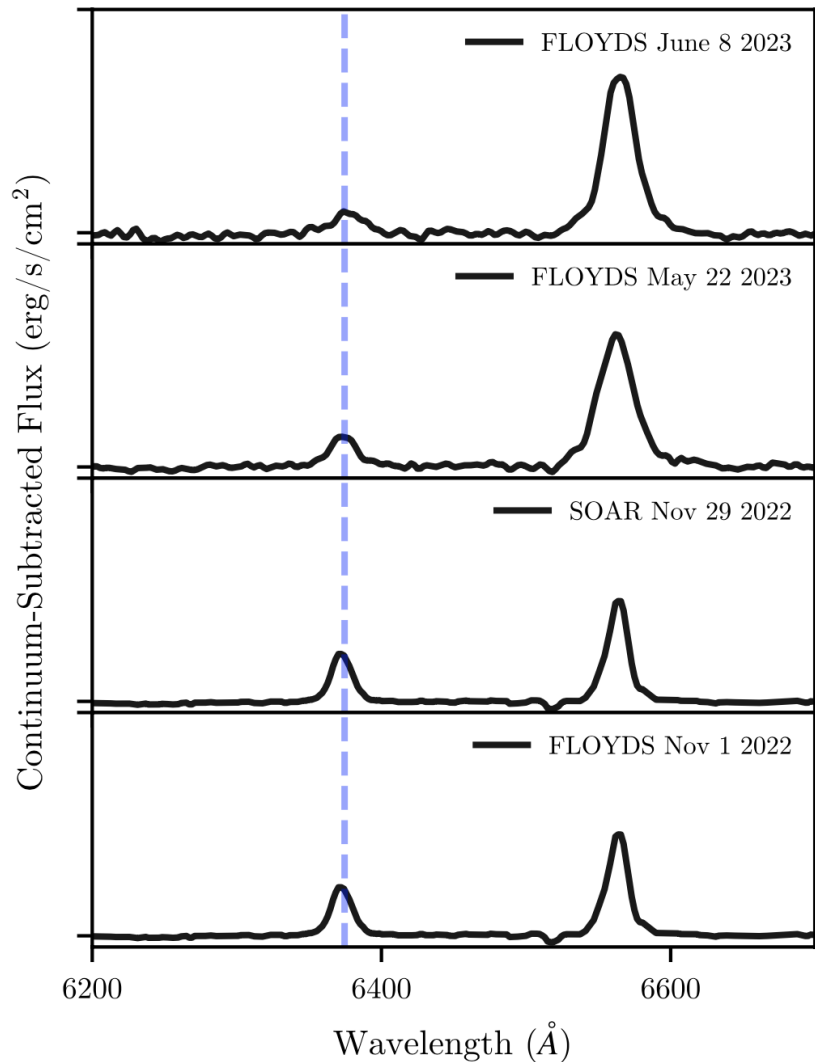


# X-ray ionizing source found concurrently!



# Bye-bye, [Fe X].....

The shorter-term evolution of forbidden iron lines has not yet been observed in TDEs, until now!



# Takeaways!

Events like AT 2020mot and AT 2022upj are novel opportunities to peer into the closest material of otherwise invisible black holes in quiet galaxies

Studying these events will explore the fundamental connections between supermassive black holes, galaxy evolution, and accretion mechanics

Let's look for X-rays, coronal lines, and near-infrared interaction signatures even earlier!