The Peculiar Einstein Probe Transient EP240408a

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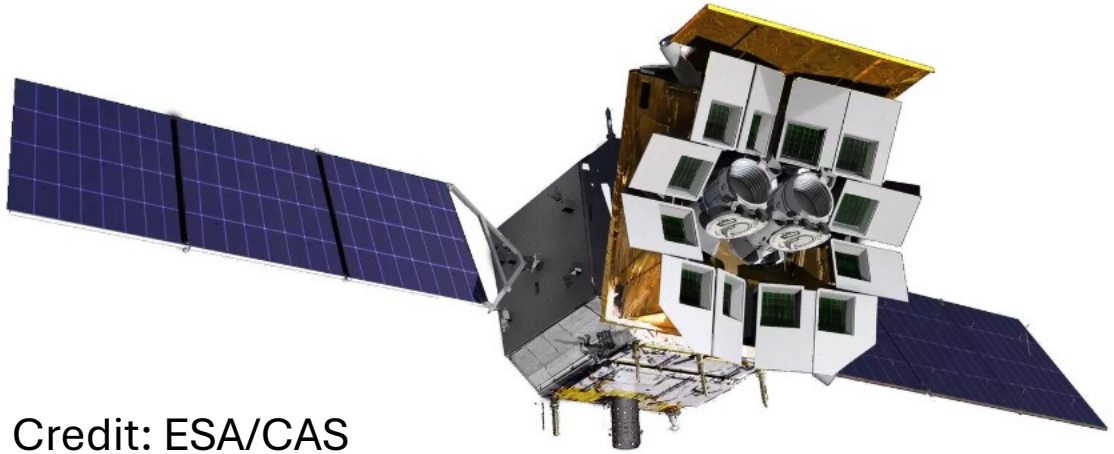
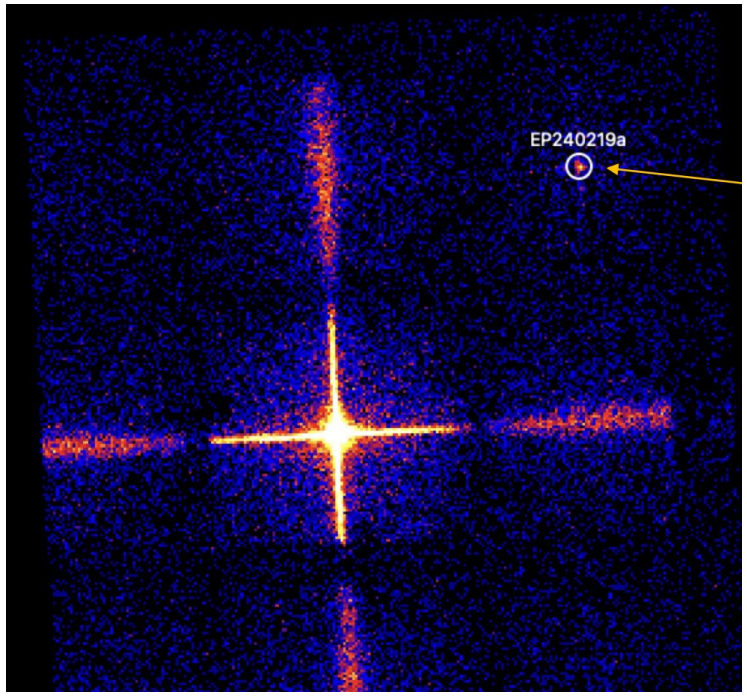
Paz Beniamini (*Open University*), et al. (*Published in ApJL*)

Einstein Probe



Credit: ESA/CAS



Credit: EP Team

Credit: ESA

Profiles of the WXT and FXT

	WXT	FXT
X-ray optics	Lobster-eye MPO	Wolter-I
Detector	CMOS	pnCCD
Effective area	~3cm ^{2} @1keV	300cm ^{2} @1.5keV (each)
FoV	~3600 deg ^{2}	~60 arcmin
Angular resolution	~5 arcmin	~20 arcsec HEW @1.5keV
Bandpass	0.5-4 keV	0.3-10 keV

- Wide-field soft X-ray survey with on-board triggers and alerts
- Many new transients detected and publicly reported through GCN circulars
- Most are not detected in gamma-rays (i.e., not typical gamma-ray bursts)

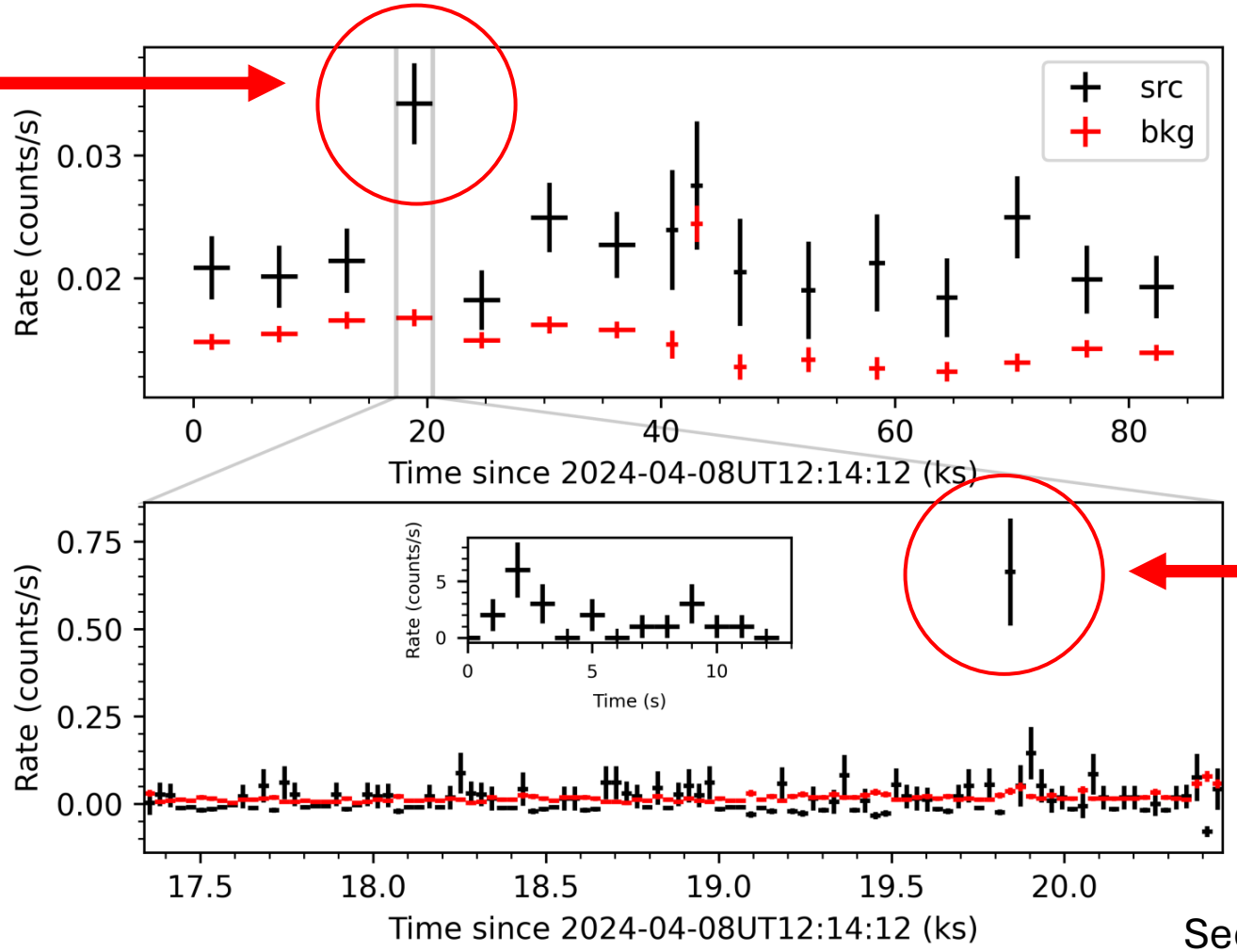
See Yuan, EP Team, et al. 2015, 2022, 2024

See talks by Yuan Liu, Peter Jonker, Qinyu Wu, and Weimin Yuan

EP240408a

- Bright 10 second soft X-ray trigger (0.5-4 keV)
- **X-ray emission for at least 21 ks prior to trigger.**
- **Onset of transient can be up to 13 days prior to trigger.**
- Unlikely to be a gamma-ray burst (GRB), even if off-axis.

EP/WXT Trigger



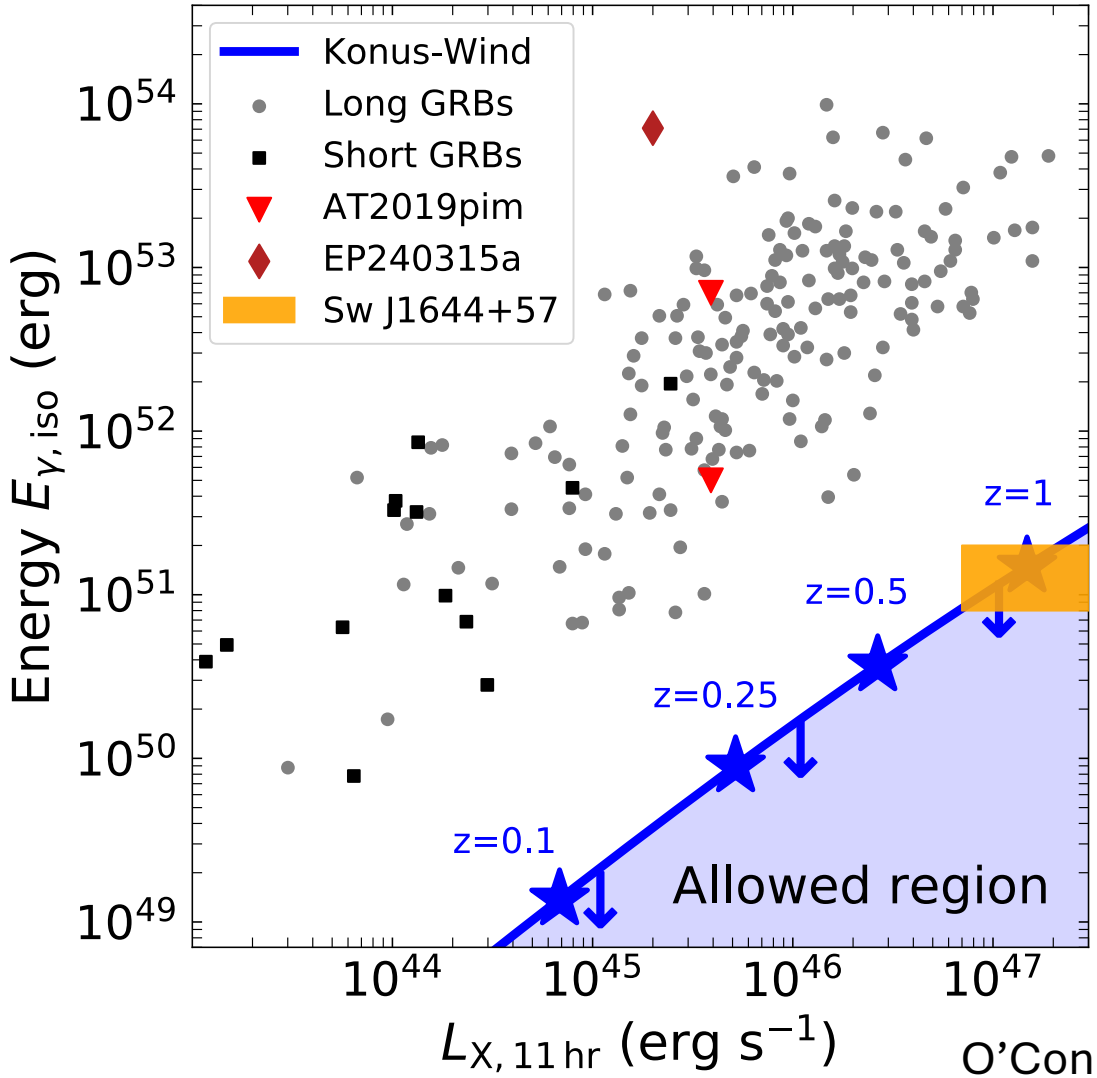
EP/WXT Trigger
~10 seconds

See Zhang, EP Team, et al. 2025

Prompt Gamma-ray Constraints

Gamma-ray limits thanks to Dmitry Svinkin & Jimmy DeLaunay

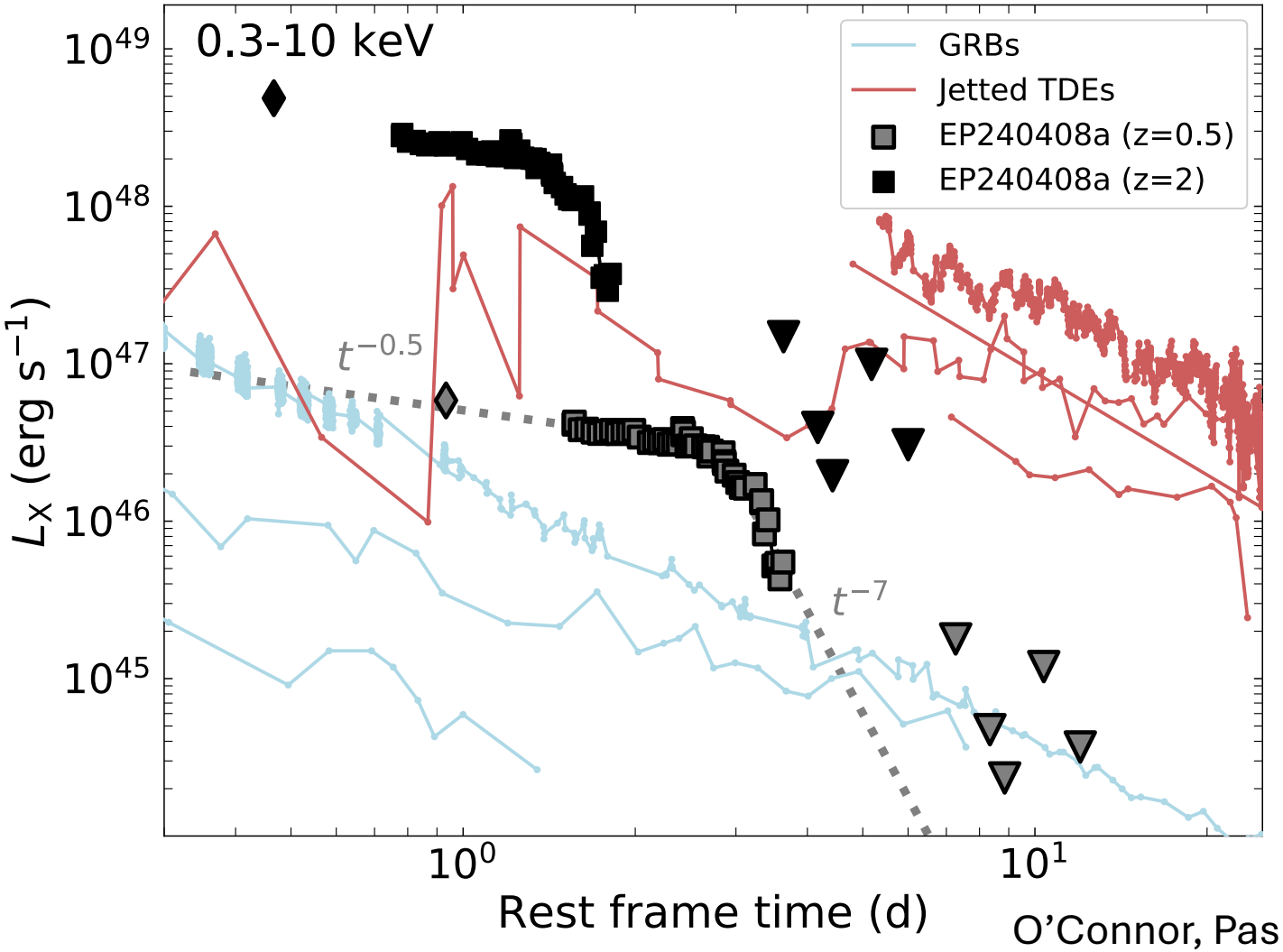
- **No gamma-ray counterpart.** Not detected by GECam-B, Konus-Wind, and Swift. *Konus-Wind is the most sensitive limit*, as out of BAT field of view.



O'Connor, Pasham, Andreoni, et al. 2025

X-ray Follow-up

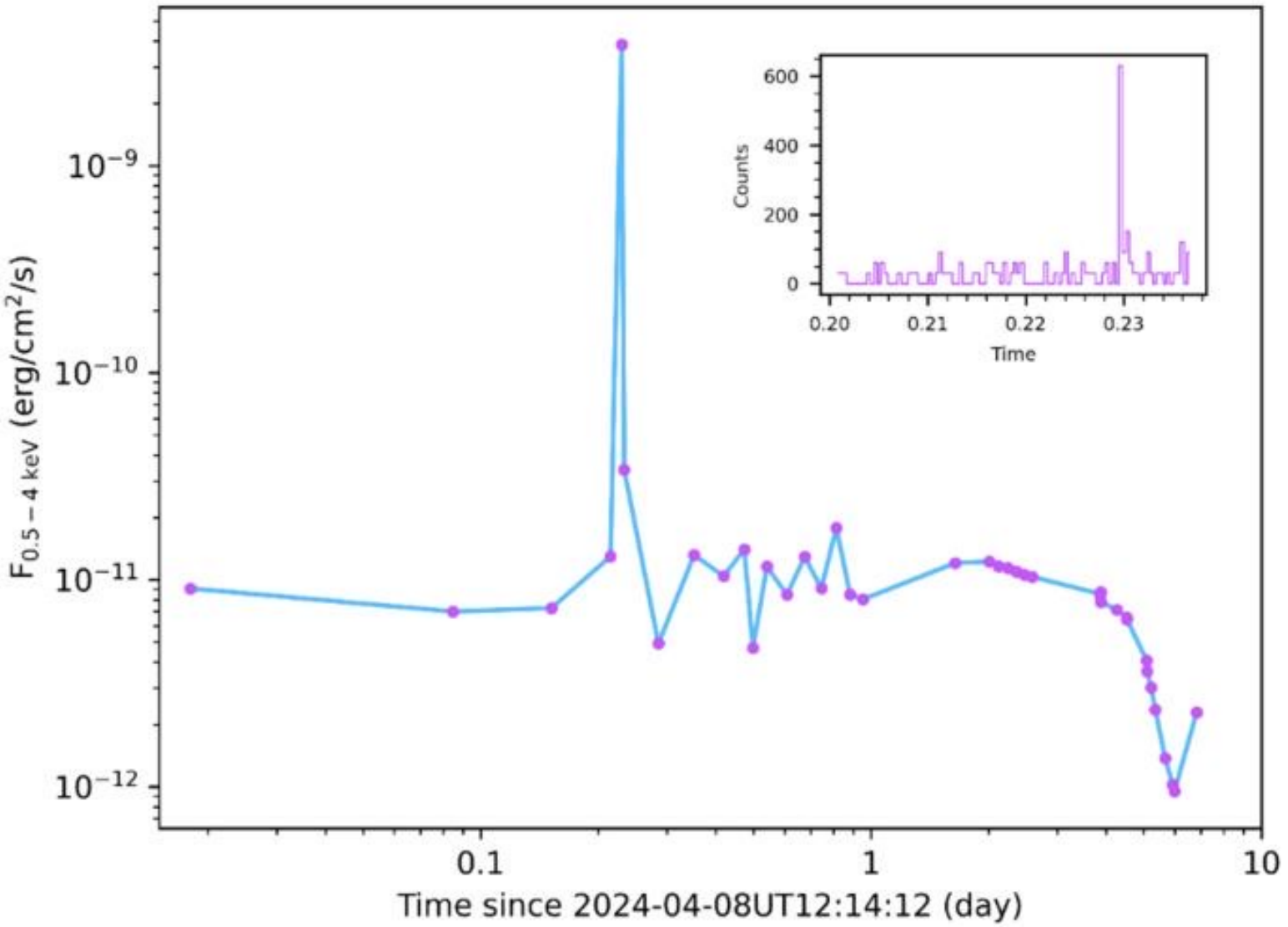
- **Swift provided localization. NICER monitoring revealed long-lived transient.**
- *X-ray lightcurve unlike other high energy transients (e.g., GRBs, TDEs).*

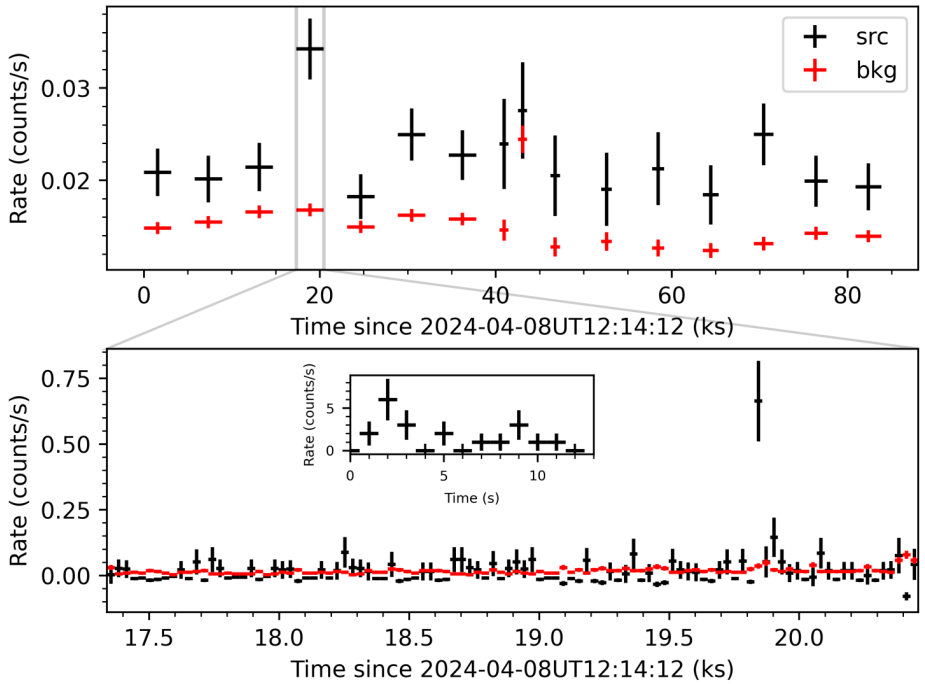


O'Connor, Pasham, Andreoni, et al. 2025

EP240408a Full X-ray Lightcurve

- T0 is from the start of EP/WXT observations of this field on 2024-04-08
- The transient onset is likely earlier (up to 13 days)

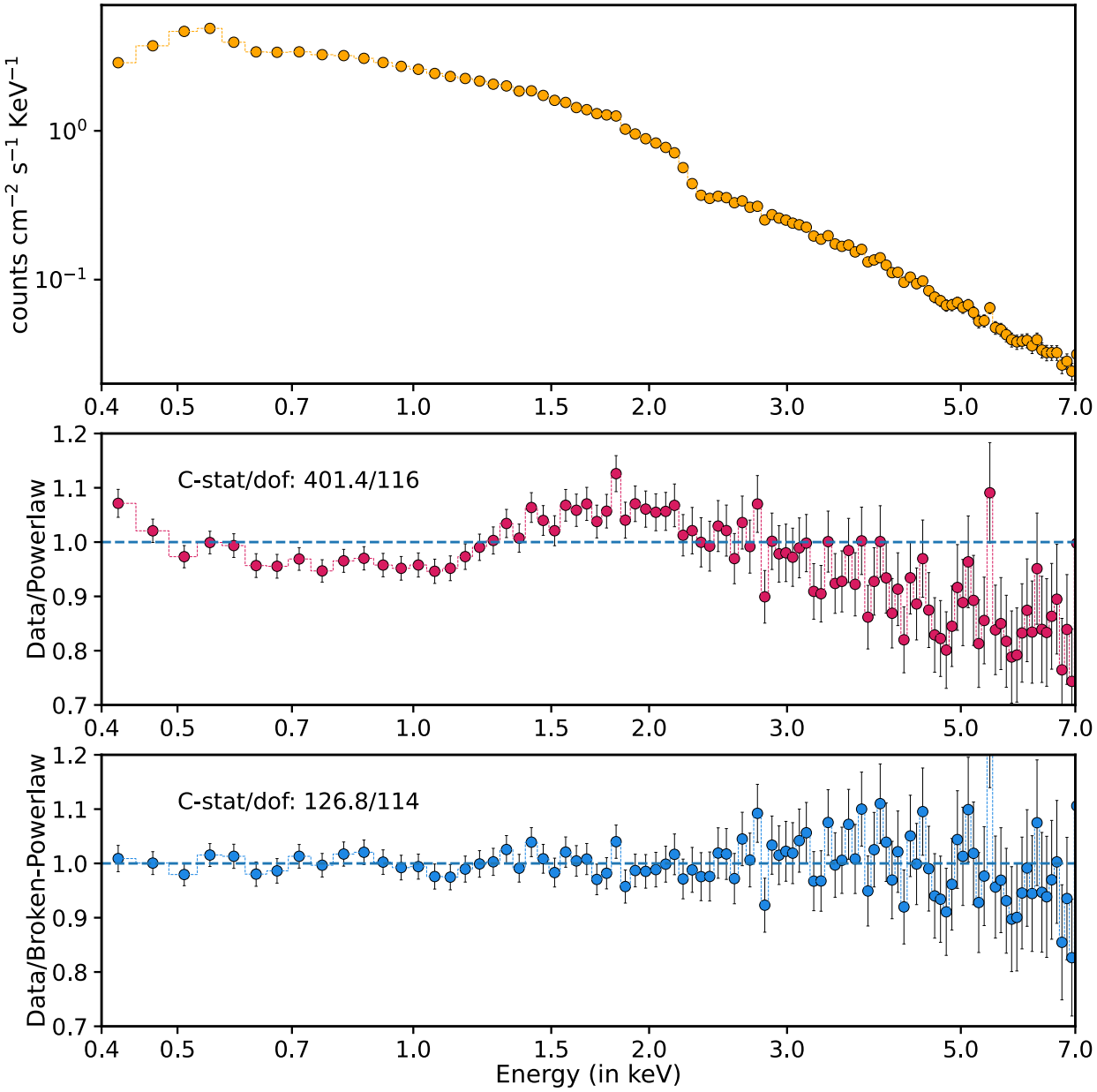


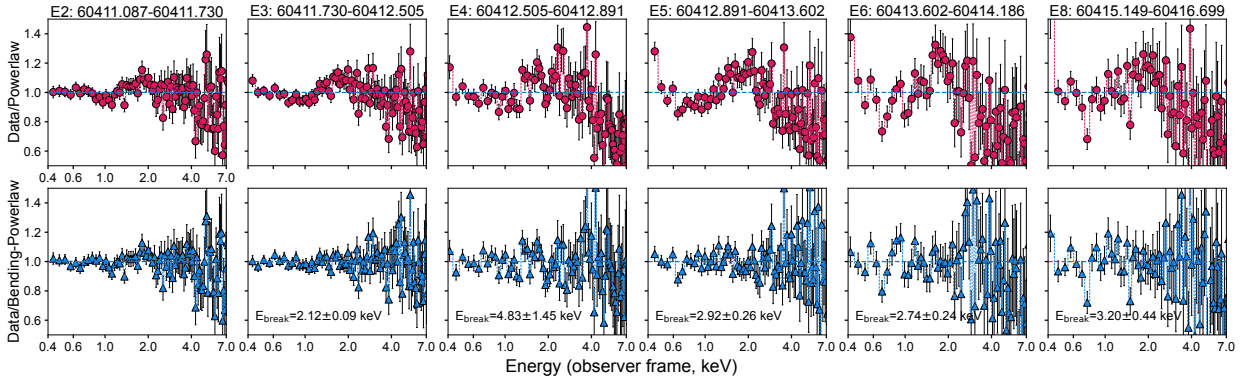


Credit: Science China Press/Eureka Alert/W. Zhang et al.
https://www.eurekalert.org/multimedia/1049269

See Zhang, EP Team, et al. 2025

EP240408a NICER X-ray Spectra



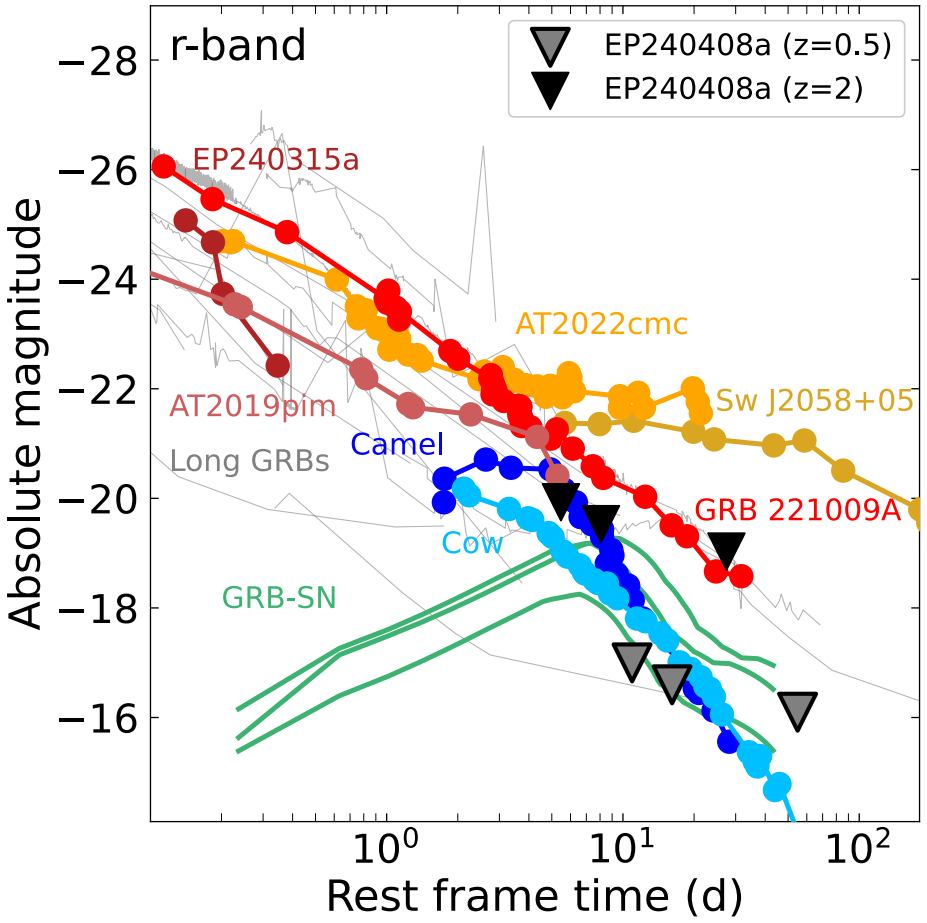


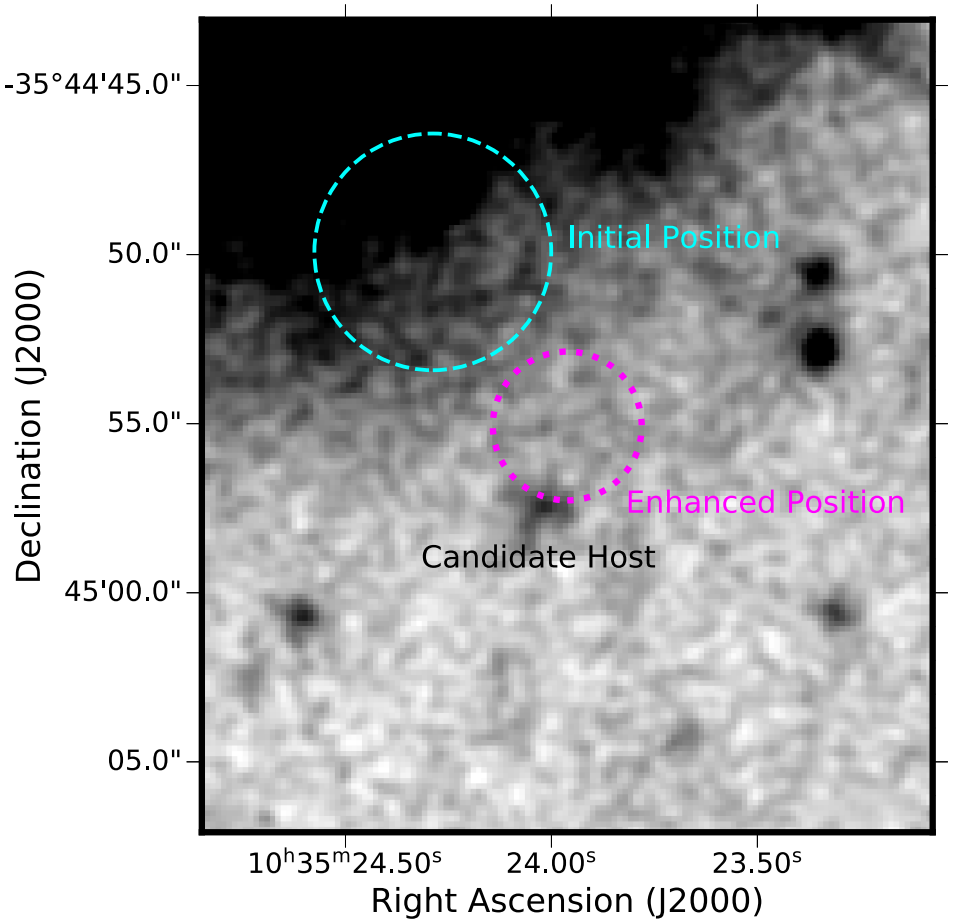
- NICER analysis using SCORPEON background modeling (*Credit to DJ*)
- NICER spectra reveal broken power-law in some epochs.
- Spectral break at ~4 keV in the observer frame. (Cooling break?)
- Significant Hydrogen column density, implies optical extinction

See O'Connor, Pasham, Andreoni, et al. 2025

Other Multi-wavelength Follow-up

- **Gemini, VLA, ATCA yielded deep upper limits.**
- Gemini uncovered a faint candidate host galaxy; *no redshift* has been acquired.

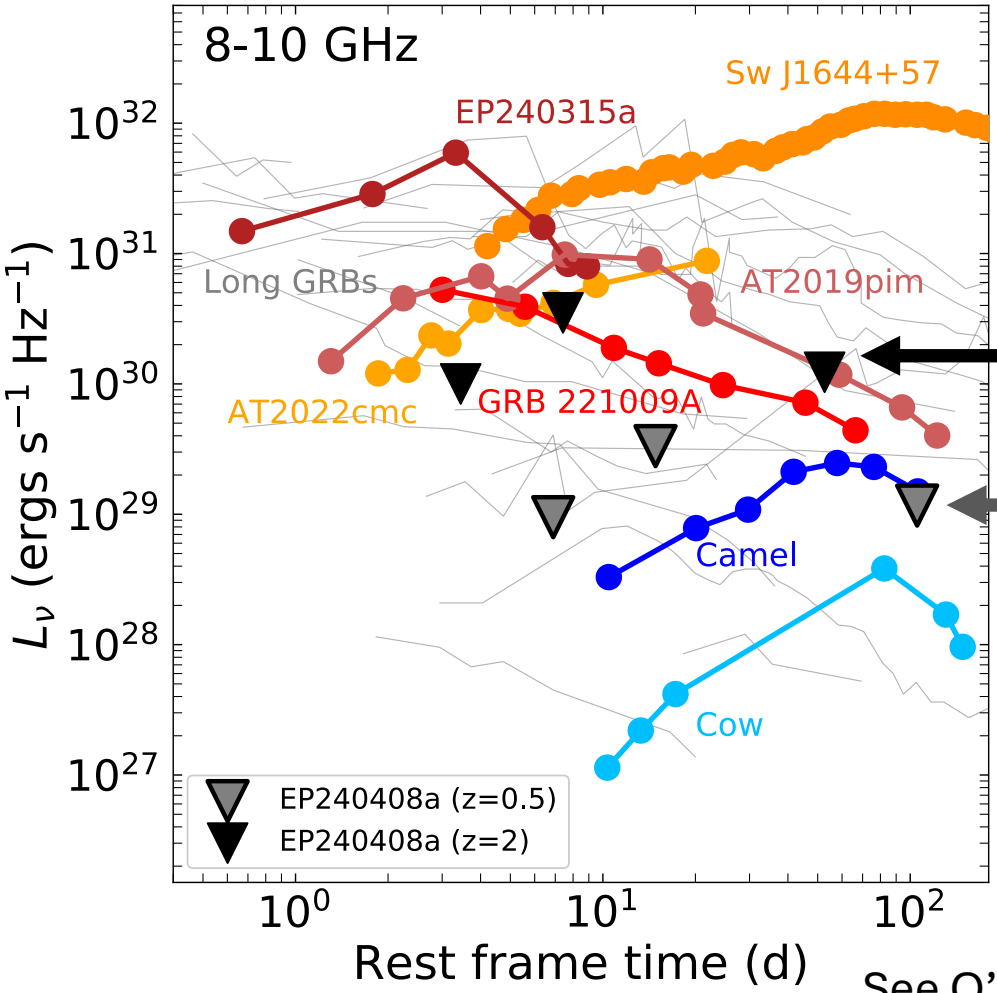




See O'Connor, Pasham, Andreoni, et al. 2025

Other Multi-wavelength Follow-up

- **Gemini, VLA, ATCA yielded deep upper limits.**
- Lack of optical may be dust; lack of radio is harder to explain



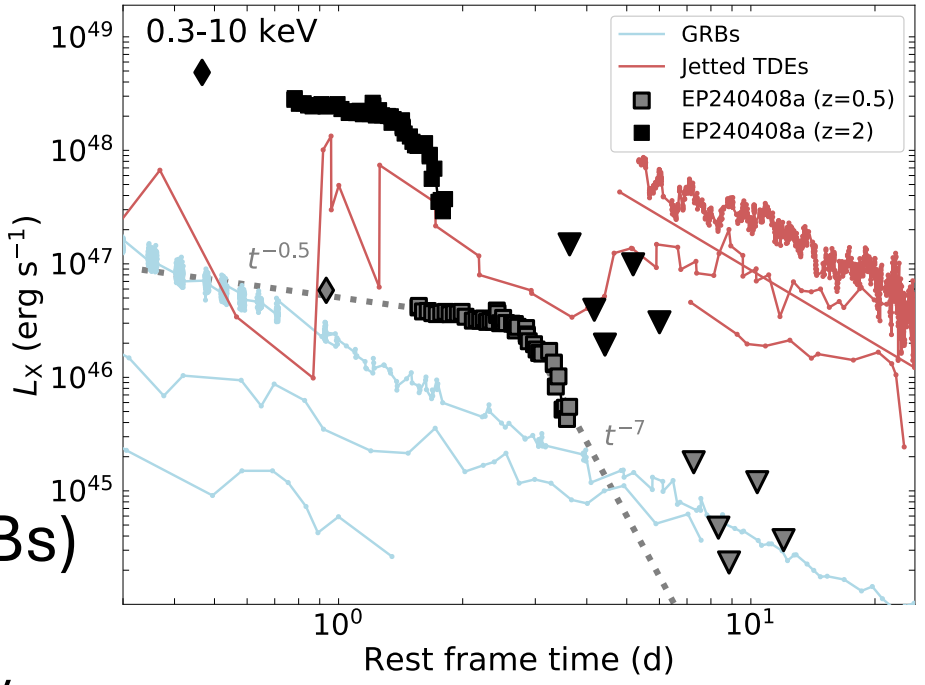
Black = Upper limits at z=2

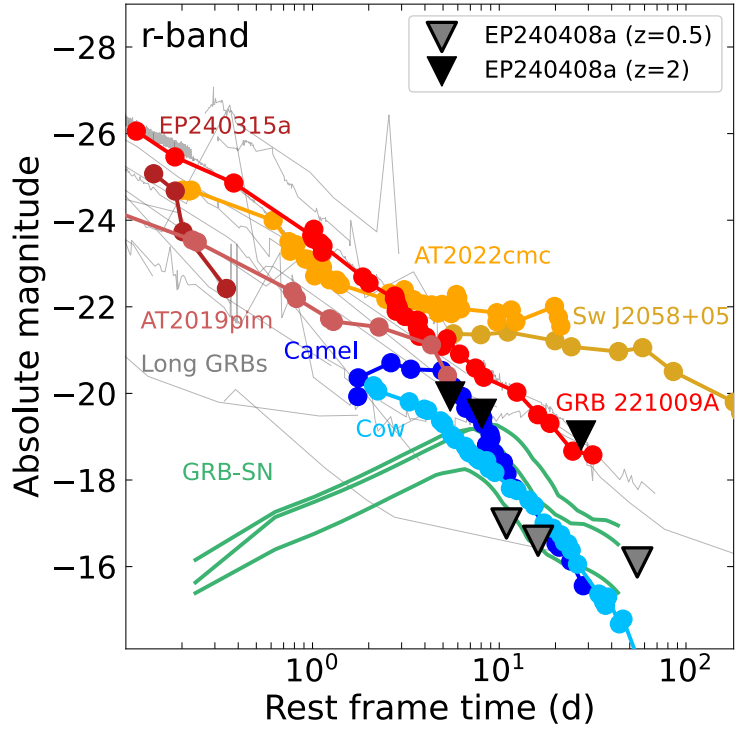
Gray = Upper limits at z=0.5

See O'Connor, Pasham, Andreoni, et al. 2025

Possible Interpretations

- We exclude:
  - Low redshift transients ($z < 0.5$)
    - e.g., lack of low-*z* host or bright optical/radio emission
  - Galactic X-ray transients (e.g., CVs, HMXBs, LMXBs)
    - High mass stars ruled out to 100 kpc
    - M dwarf ruled out to 15 kpc → X-ray burst is >1e39 erg/s
    - Lack of X-ray pulsations, even in accelerated search
  - Fast Blue Optical Transients (FBOTs)
    - Lack of optical emission and much lower X-ray luminosity unless <60 Mpc
  - Fast X-ray Transients (FXTs)
    - Shorter timescales and low luminosities





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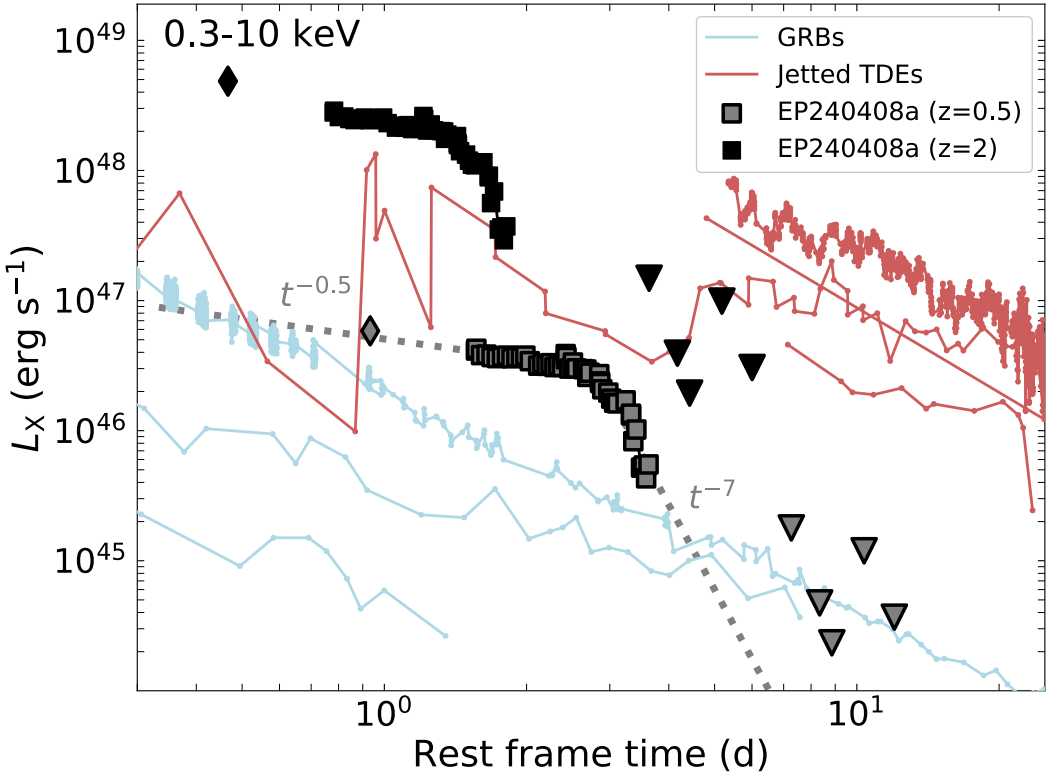
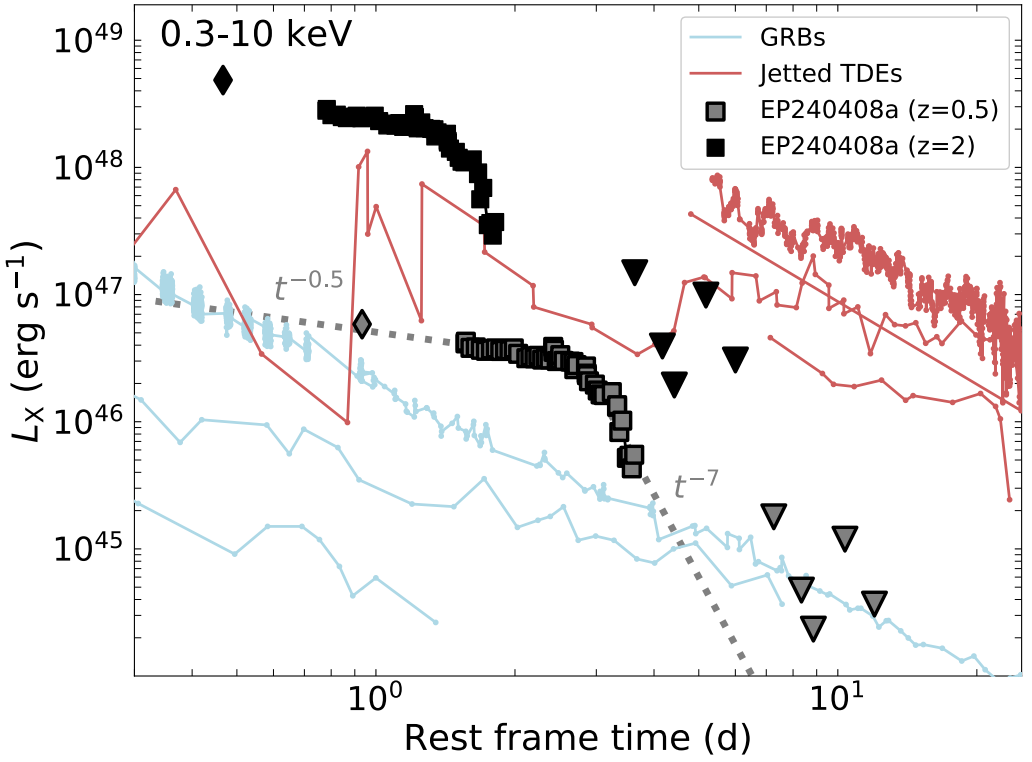
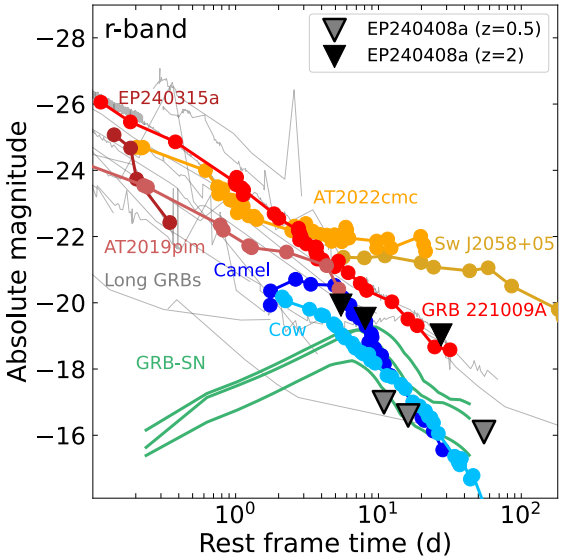


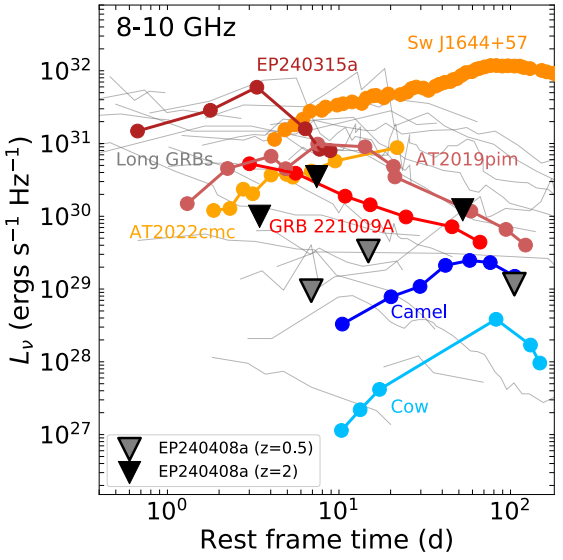
- **A new class of X-ray transient?**
- Unlike any known Gamma-ray burst
  - e.g., lack of gamma-rays, plateau duration, and long-long lasting emission prior to trigger (Zhang+25)
- **Closest to relativistic jetted Tidal Disruption Events (TDEs) at $z > 1$**
  - Lack of luminous radio may be explained by delayed deceleration of the jet
  - *Potentially caused by disruption of a **White Dwarf by an Intermediate Mass Black Hole***
  - ***Onset of disruption may have been up to 13 days prior to trigger.***
- **Future observations of similar transients are critical to determine its nature.**

Conclusions

- **EP240408a is a strange and potentially new high energy transient.**
- Future radio observations may reveal the presence of delayed emission from a jet.
- **Rapid space-based follow-up of similar EP transients are critical to determine its nature.**







See O'Connor, Pasham, Andreoni, et al. 2025
and Zhang, EP Team, et al. 2025

See talks by Yuan Liu, Peter Jonker, Qinyu Wu, and Weimin Yuan


Thank you!

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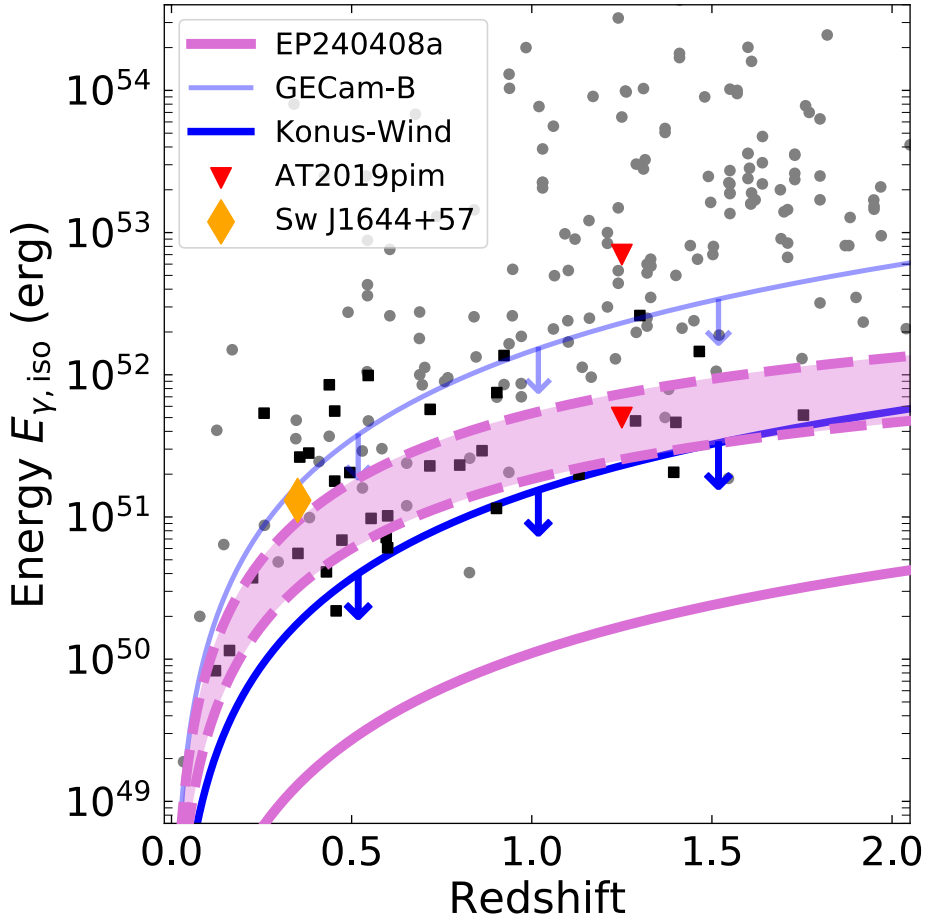
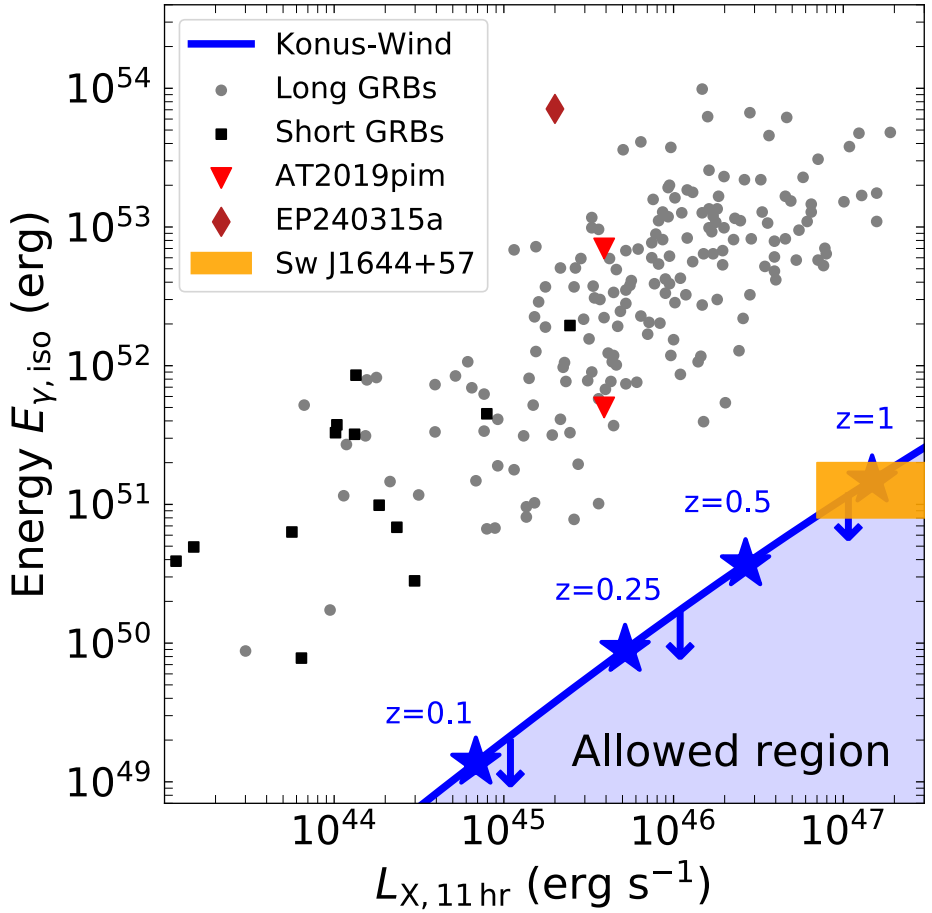


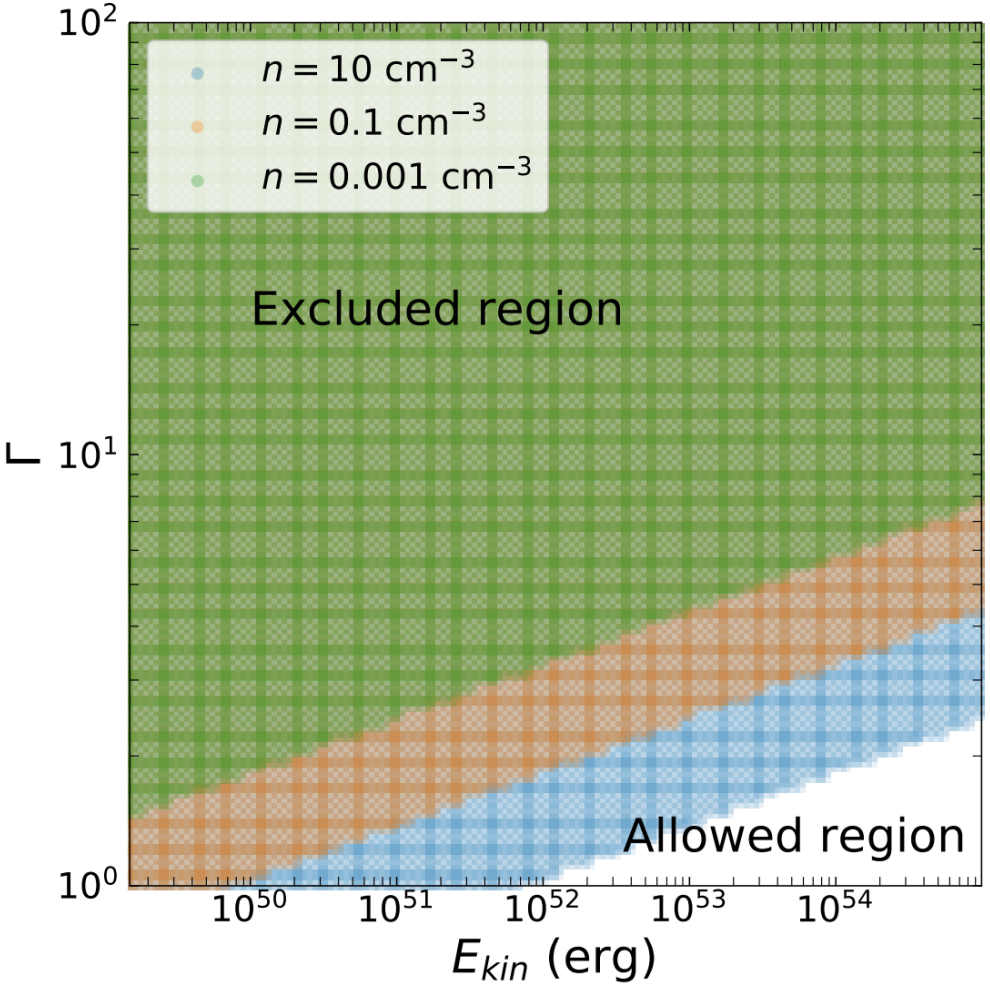


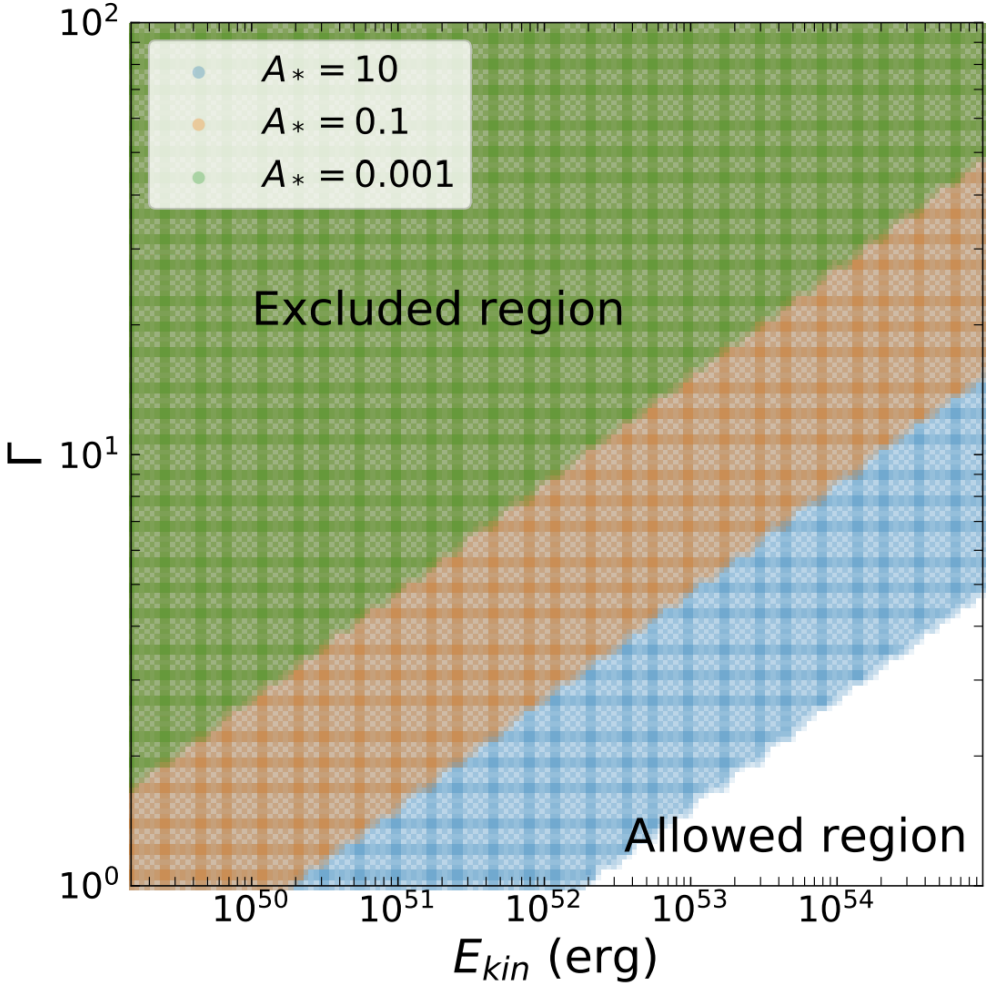
Unlikely to be a gamma-ray burst (GRB), even if off-axis.

See O'Connor, Pasham, Andreoni, et al. 2025 and Zhang, EP Team, et al. 2025

Allowed Parameters for Delayed Deceleration

- **Delayed radio emission is observed in TDE jets out to years after discovery**
- A mildly relativistic outflow may explain the lack of radio, and may eventually become detectable





Allowed Parameters for Non-Detection of Afterglow

- Applies to GRB and TDE jets.
- Non-detection requires small densities or low microphysical parameters