



# Soft X-ray prompt emission from the high-redshift gamma-ray burst EP240315a

Y. Liu et al., 23 January 2025, nature astronomy

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# 1. Trigger and follow-up

Trigger info: EP240315a

- Trigger time: 2024.3.15 20:10:44 (utc)
- Band : soft X ray (0.5–4keV)
- Facility : EP/WXT

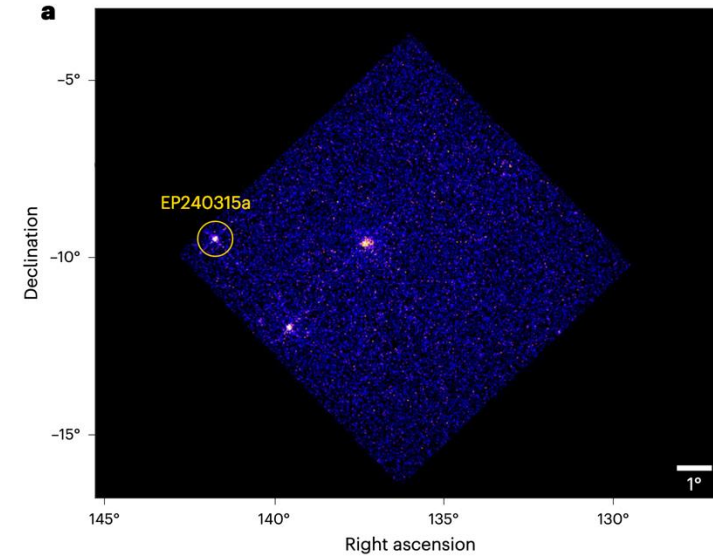
Follow up:

- ATLAS: T0 + 1.1 h, optical counterpart
- MeerKAT: T0 + 2.86 d, radio counterpart
- VLT: **redshift = 4.859**

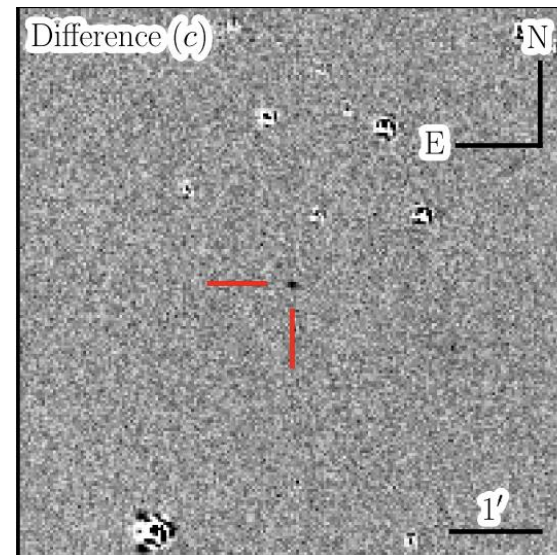
Off-line analysis:

- GRB 240315C : Swift/BAT and Konus-Wind

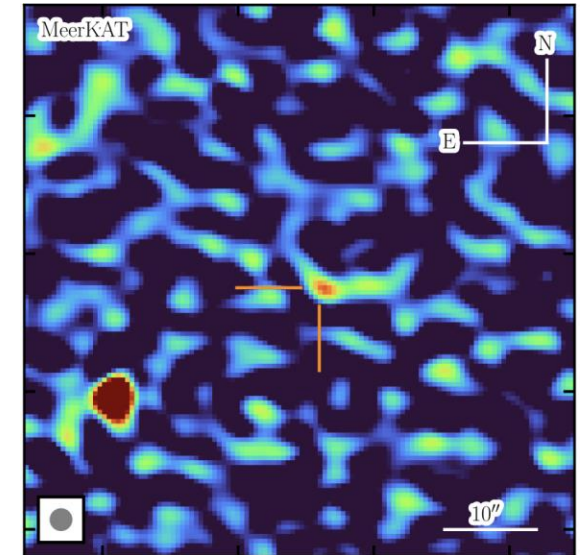
EP/WXT



ATLAS

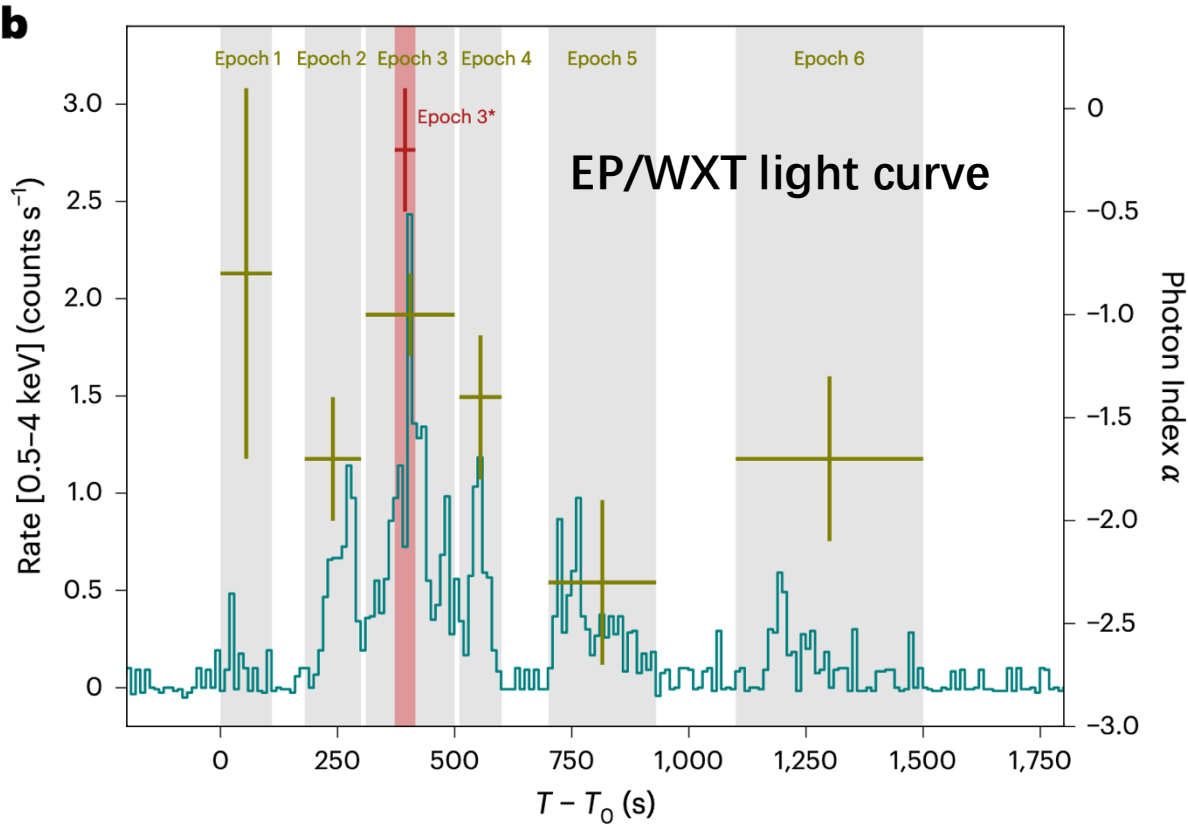


MeerKAT



# 2. Light curve

- The WXT light curve exhibits multipeaked structure.
- $T_{90,X} \approx 1034 \pm 81 \text{ s}$ ,  $T_{90,\gamma} \approx 38 - 41 \text{ s}$  (red shaded)
- Soft X ray (WXT) triggering earlier than the gamma rays (BAT + Konus-Wind) by 372 s.

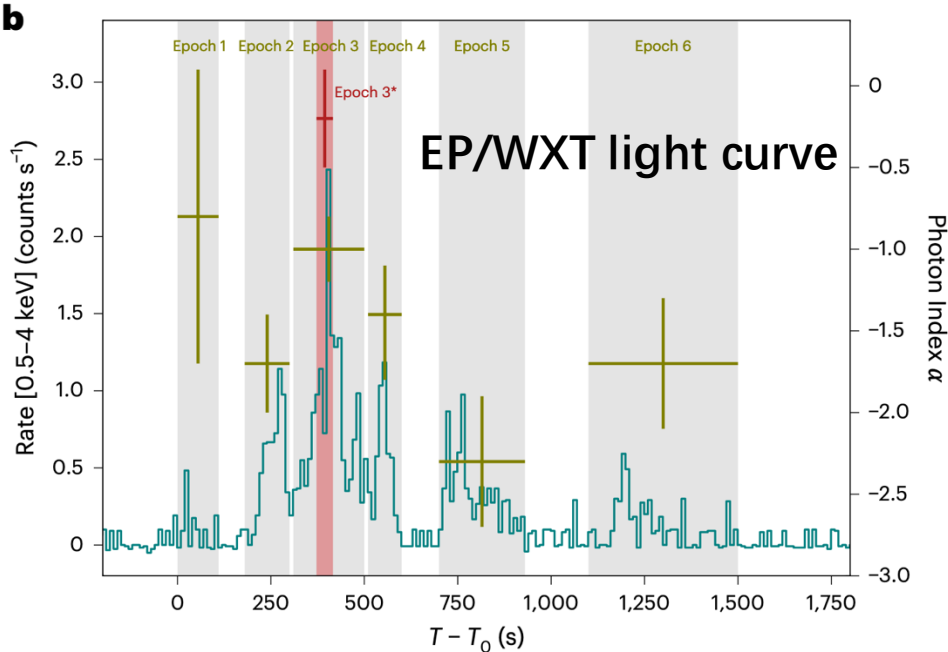


**Table 1 | Observational properties of the prompt emission**

Observed properties	EP-WXT 0.5–4 keV	Swift-BAT 15–350 keV	Konus-Wind 23–1,618 keV
$T_{90}$ (s) <sup>a</sup>	1,034±81	41.6±1.6	38±3
$\alpha$ <sup>b</sup>	$-1.4^{+0.1}_{-0.1}$	$-0.7^{+0.5}_{-0.4}$	$-1.2^{+0.2}_{-0.1}$
Peak flux (erg cm <sup>-2</sup> s <sup>-1</sup> )	$4.6^{+0.8}_{-0.7} \times 10^{-9}$	$(4.9 \pm 0.5) \times 10^{-7}$	$8.7^{+1.7}_{-1.6} \times 10^{-7}$
Peak luminosity (erg s <sup>-1</sup> )	$(1.2 \pm 0.2) \times 10^{51}$	$(1.2 \pm 0.1) \times 10^{53}$	$(2.2 \pm 0.4) \times 10^{53}$
Total fluence (erg cm <sup>-2</sup> ) <sup>b</sup>	$(1.0 \pm 0.1) \times 10^{-6}$	$(6.6 \pm 0.4) \times 10^{-6}$	$(1.8 \pm 0.2) \times 10^{-5}$
<b>1–10,000 keV</b>			
Isotropic energy (erg) <sup>c</sup>	$6.4^{+0.4}_{-0.8} \times 10^{53}$		

### 3. Temporal and spectral behaviours

- The spectra fitted in each epoch exhibit a signature of evolution with a generally harder spectrum observed during an epoch of higher intensity



**Table 2 | The fitting results and corresponding fitting statistics for the time-sliced prompt emission spectra**

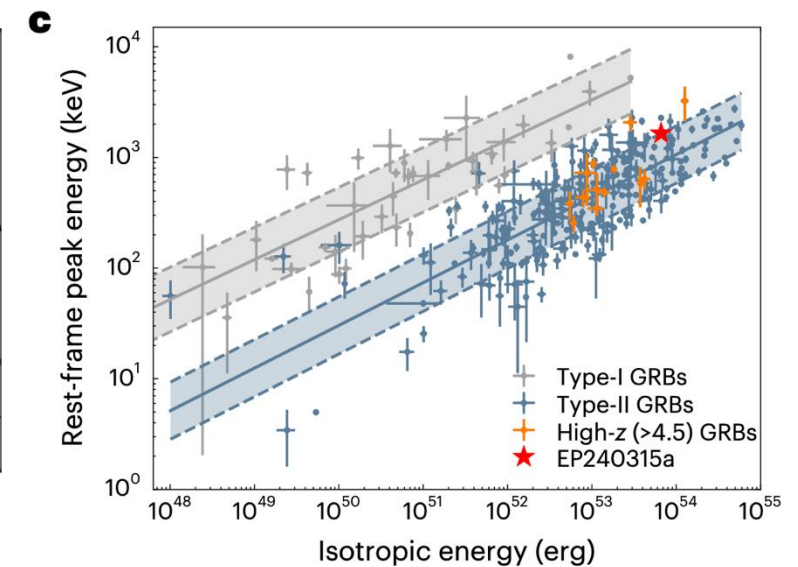
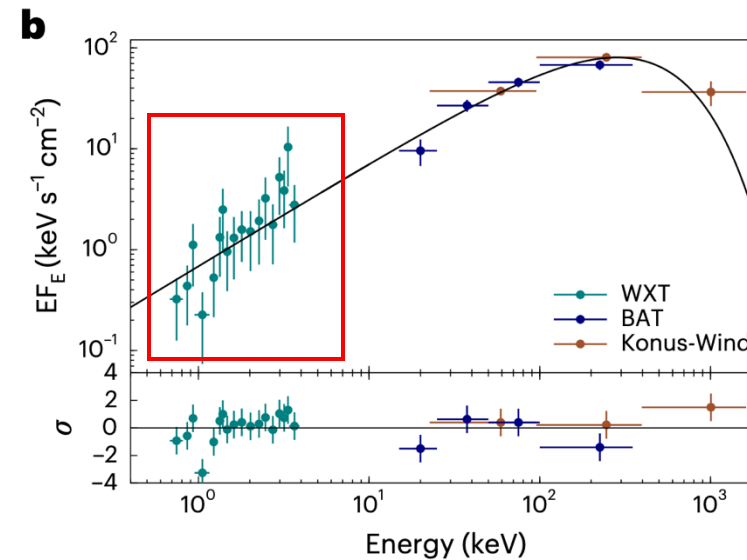
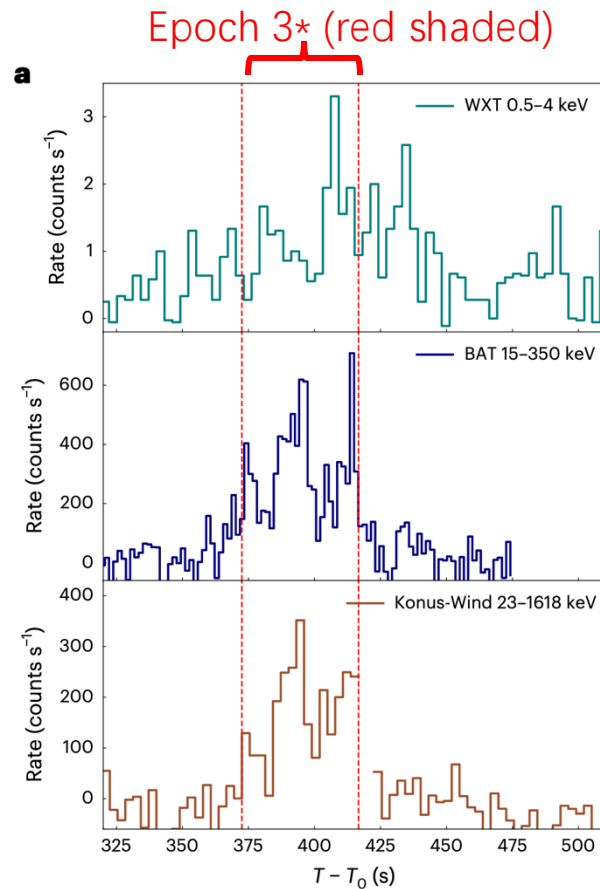
Instruments	Spectrum	Time interval(s)	Model	$\alpha$	$E_{\text{peak}}(\text{keV})^a$	Flux <sup>b</sup> (erg cm <sup>-2</sup> s <sup>-1</sup> )	CSTAT/(d.o.f.) <sup>c</sup>
WXT	Total	0–1,500	PL	$-1.4^{+0.1}_{-0.1}$	—	$6.1^{+0.4}_{-0.4} \times 10^{-10}$	45.21/38
	Epoch 1	0–110	PL	$-0.8^{+0.9}_{-0.9}$	—	$2.2^{+1.4}_{-1.0} \times 10^{-10}$	11.57/1
	Epoch 2	180–300	PL	$-1.7^{+0.3}_{-0.3}$	—	$9.5^{+1.9}_{-1.6} \times 10^{-10}$	21.29/17
	Epoch 3	310–500	PL	$-1.0^{+0.2}_{-0.2}$	—	$2.2^{+0.3}_{-0.3} \times 10^{-9}$	42.09/46
	Epoch 4	510–600	PL	$-1.4^{+0.3}_{-0.4}$	—	$1.3^{+0.3}_{-0.3} \times 10^{-9}$	14.99/15
	Epoch 5	700–930	PL	$-2.3^{+0.4}_{-0.4}$	—	$4.7^{+0.9}_{-0.7} \times 10^{-10}$	23.83/22
	Epoch 6	1,100–1,500	PL	$-1.7^{+0.4}_{-0.4}$	—	$2.3^{+0.5}_{-0.5} \times 10^{-10}$	7.90/13
	Epoch 3*	372–416	PL	$-0.2^{+0.3}_{-0.3}$	—	$4.6^{+0.8}_{-0.7} \times 10^{-9}$	11.38/16



### 3. Temporal and spectral behaviours

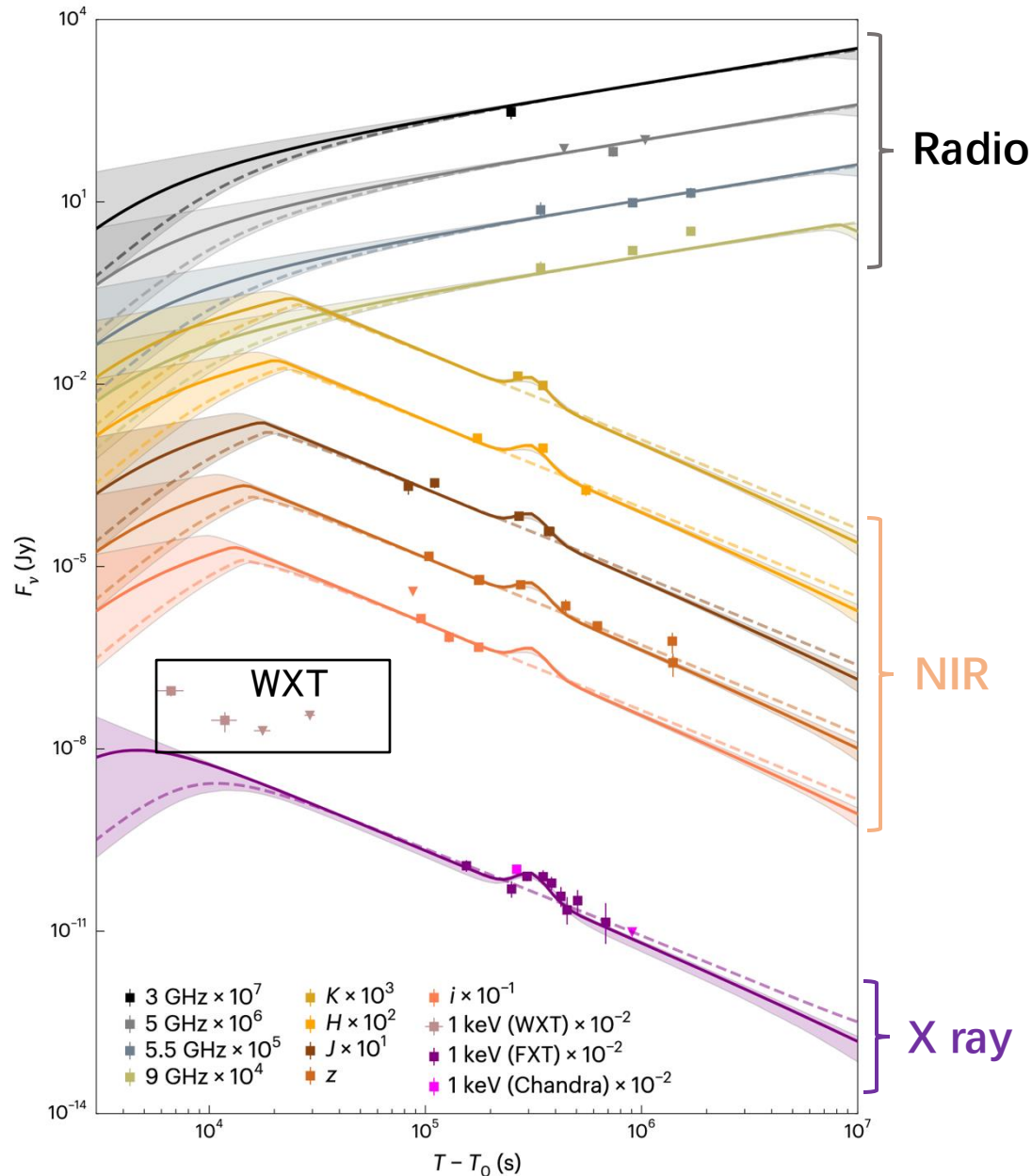
- The spectral lag analysis implies that the light curve of WXT is delayed with respect to that of BAT by  $10.7 \pm 1.1$  s

- Common origin (likely): X ray and gamma ray; related to internal dissipation in the ejecta.
- Epoch 3\*: gamma-ray emission aligns with the peak flux and the hardest spectrum in the X-rays,
- Implying the observed gamma-ray emission may be just a fraction of the total.



Instruments	Spectrum	Time interval(s)	Model	$\alpha$	$E_{\text{peak}}$ (keV) <sup>a</sup>	Flux <sup>b</sup> (erg cm <sup>-2</sup> s <sup>-1</sup> )	1-10,000 keV
WXT+BAT+Konus-Wind	Epoch 3*	372-416	CPL	$-0.97^{+0.06}_{-0.05}$	$283^{+65}_{-47}$	$3.4^{+0.2}_{-0.4} \times 10^{-7}$	Isotropic energy (erg) <sup>c</sup> $6.4^{+0.4}_{-0.8} \times 10^{53}$

## 4. Multiwavelength afterglow



- EP/FXT :  $T_0 + 42 \text{ h} - T_0 + 8 \text{ d}$ .
- Chandra X ray obs. :  $T_0 + 72 \text{ h}$  ,  $T_0 + 10.4 \text{ d}$ .
- EP launched a campaign to monitor the afterglow in the g, r, i, z, R, White, J, H and K bands and in radio at 5 GHz, 5.5 GHz and 9.0 GHz.
- Rebrightening structure :  $T_0 + 200 \text{ ks} - T_0 + 500 \text{ ks}$
- The standard GRB afterglow model could well interpret the multiwavelength follow-up data.

# 5. Comparison with other high- $z$ GRBs (Swift/BAT)

