GRB 211211A

Clément Pellouin – High-Energy Journal Club – 12 May 2022

A Kilonova Following a Long-Duration Gamma-Ray Burst at 350 Mpc

2204.10864

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A minute-long merger-driven gamma-ray burst from fast-cooling synchrotron emission

2205.05008

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A peculiarly long-duration gamma-ray burst from binary neutron star merger

Jun Yang,[1,2] Bin-Bin Zhang,[1,2] Shunke Ai,[3,4] Zi-Ke Liu,[1,2] Xiangyu Ivy Wang,[1,2] Ye Li,[5] Hou-Jun Lü,[6] and Bing Zhang[3,4]

2204.12771

The quasi-periodically oscillating precursor of a long gamma-ray burst from a binary neutron star merger

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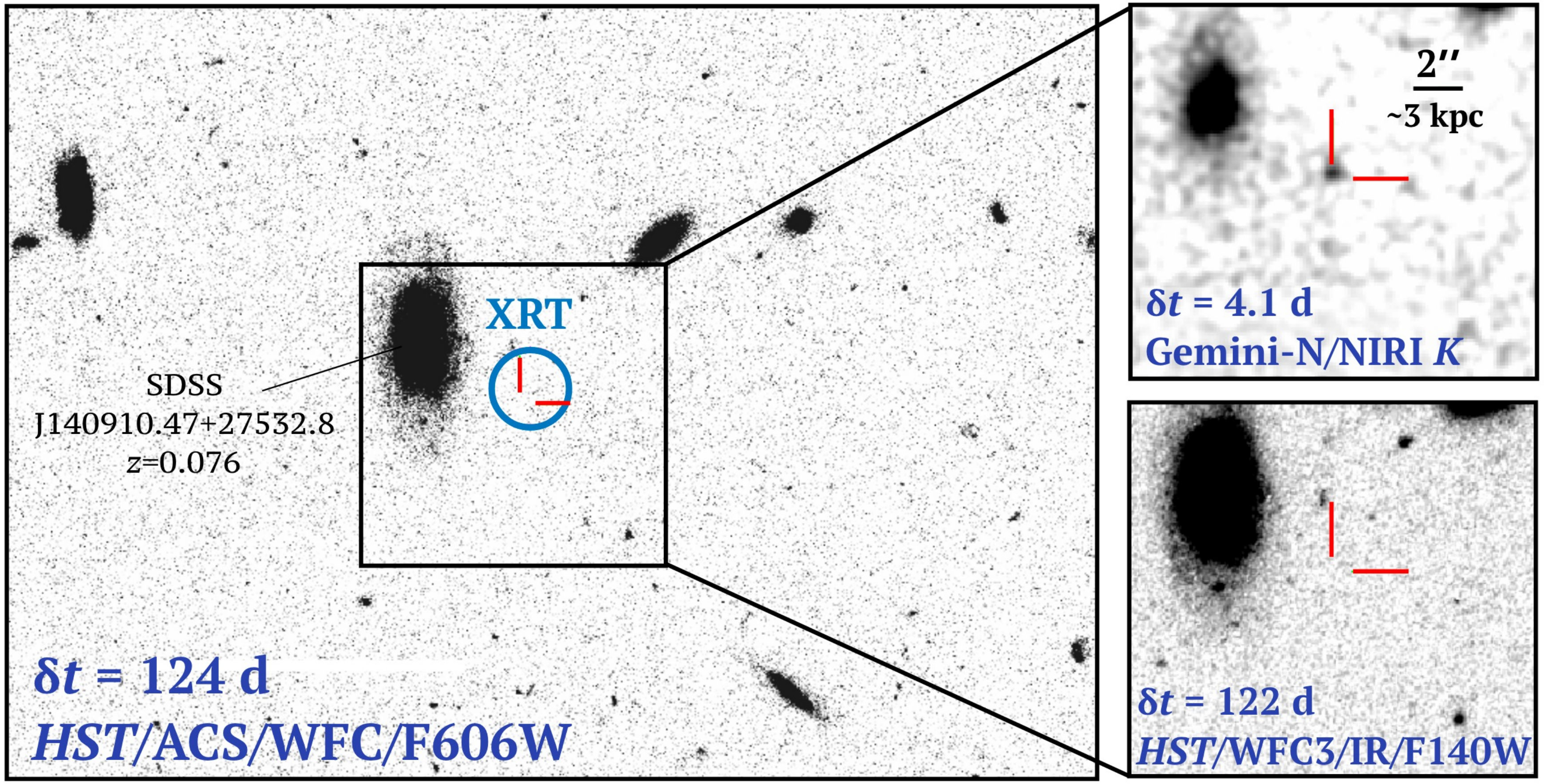
2205.02186

GRB 211211A: prolonged central engine under strong magnetic field environment

He Gao,[1] Wei-Hua Lei,[2] and Zi-Pei Zhu[2,3]

2205.05031

Host galaxy identification



SDSS J140910.47+27532.8

D ~ 350Mpc (z = 0.076)

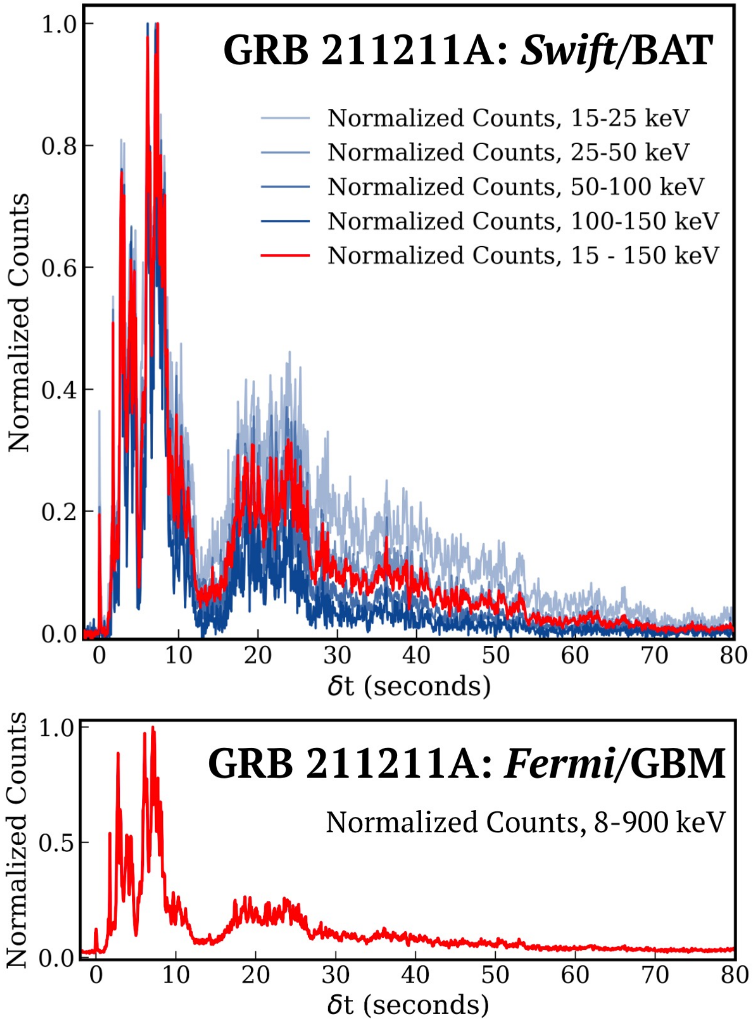
Source offset: 7.9 kpc

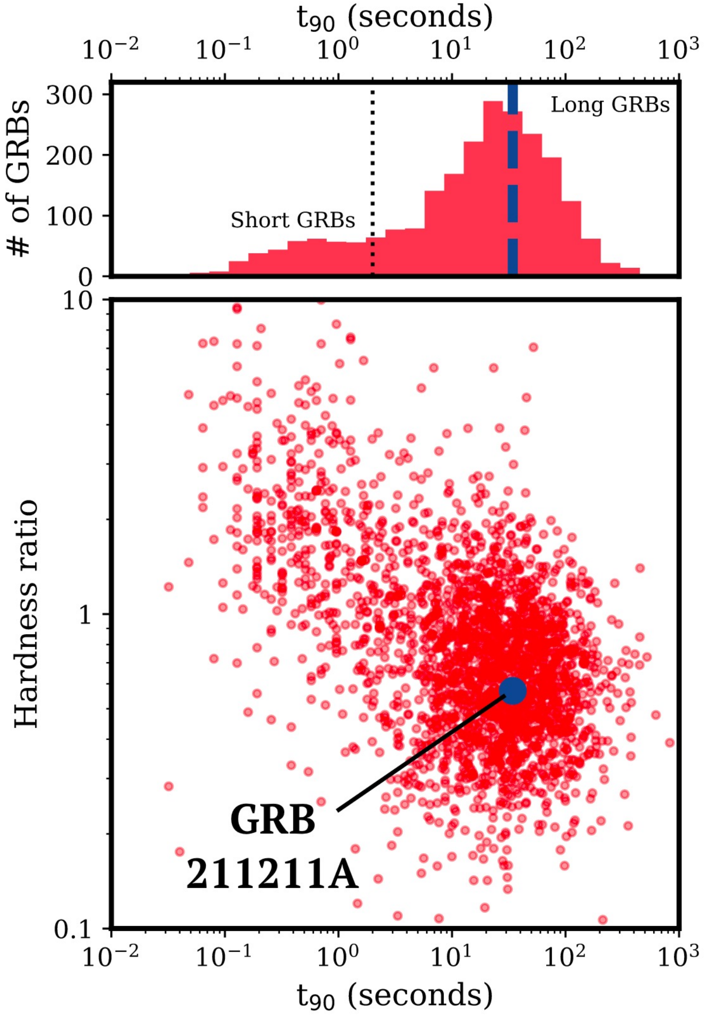
No source at the position of the optical afterglow to F606W > 27.76 mag and F140W > 27.19 AB mag.

→

No galaxy brighter than 1% L* at this location for z < 1.4

Prompt emission



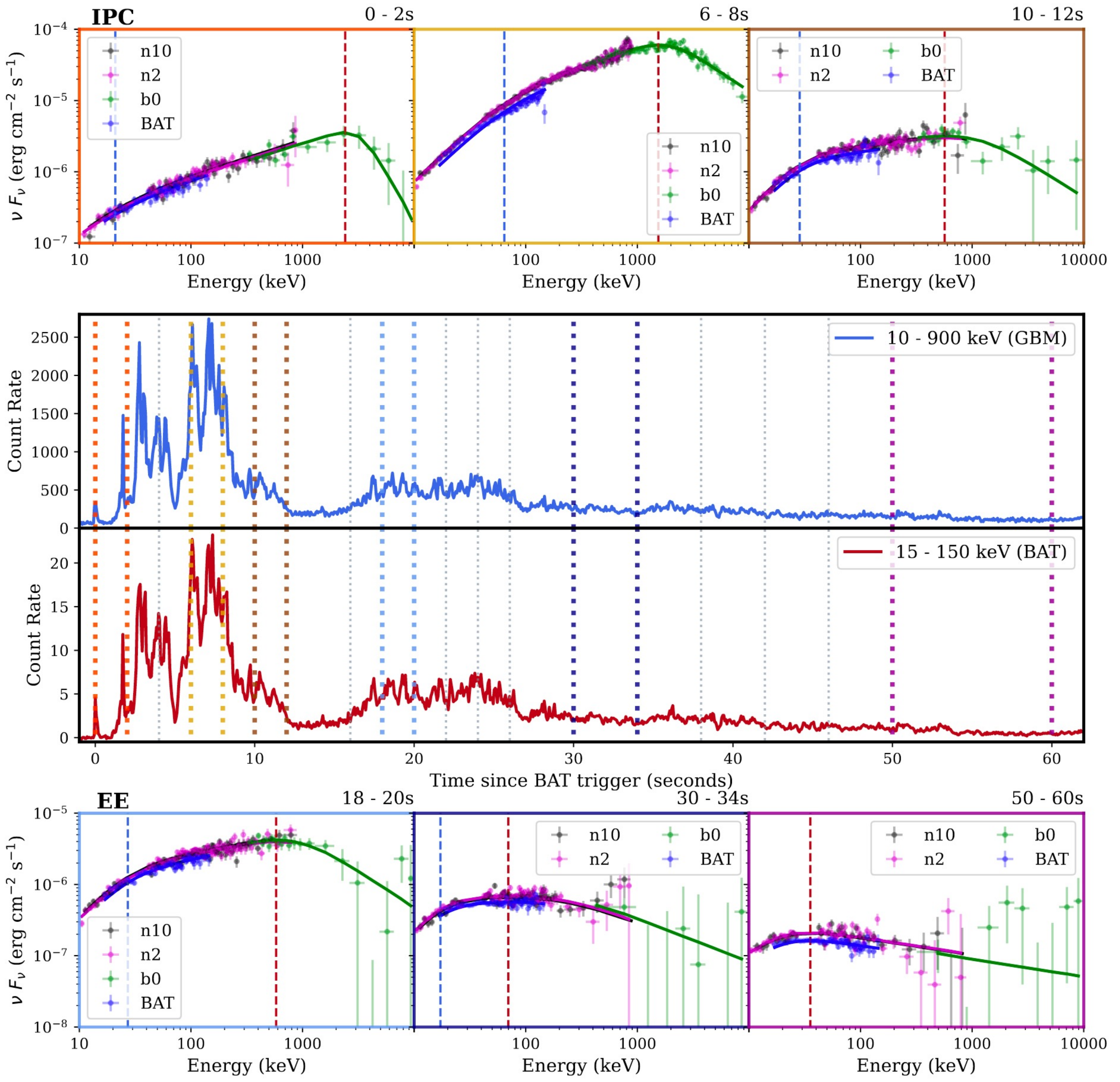


- T_{90} = 51s
- Typical lGRB hardness ratio
- Several overlapping pulses
- Softer extended emission

→ Much longer duration than usually searched for EE-GRB

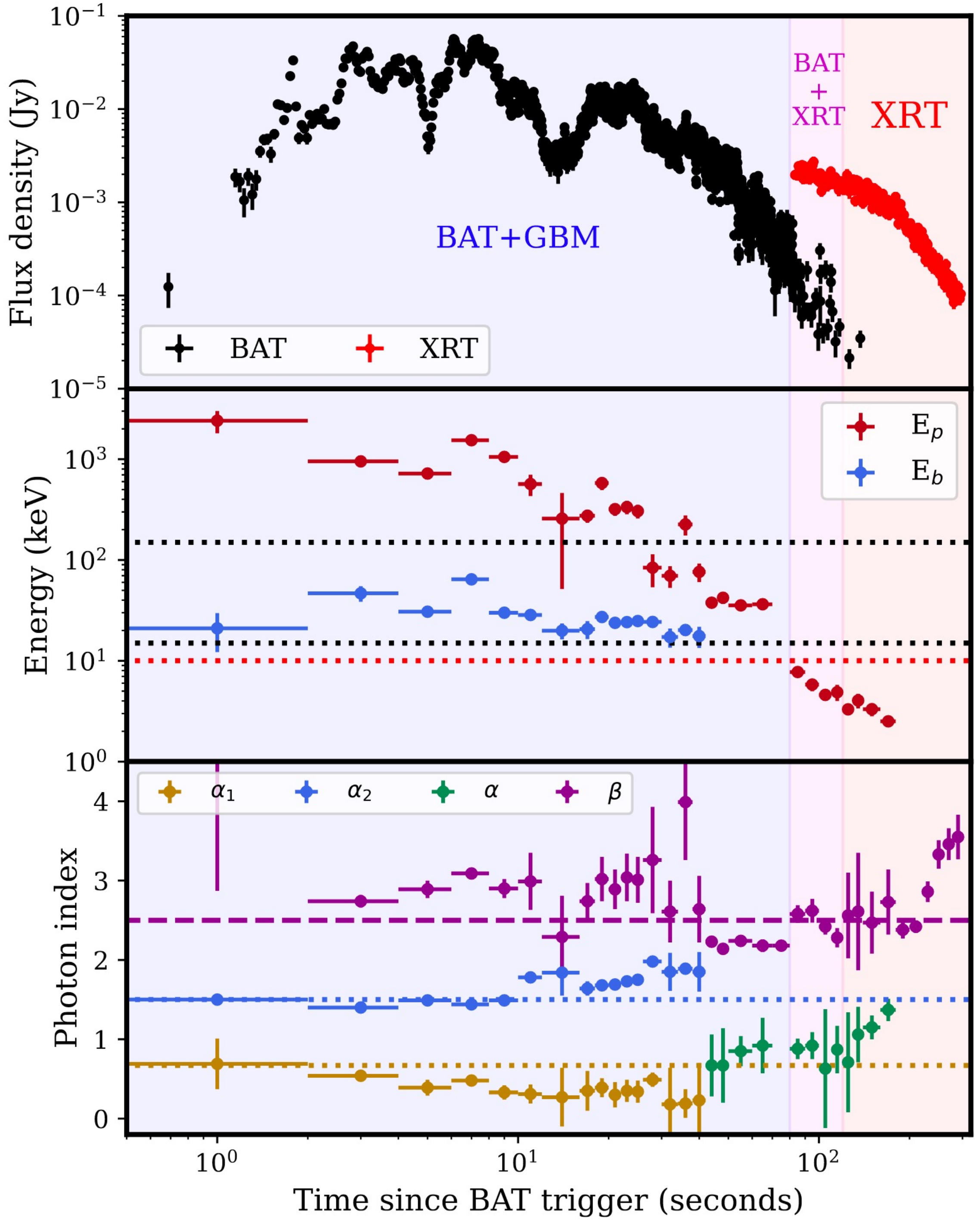
Spectral evolution

Double Smoothly Broken Power Law (2SBPL) favored over Band or Band+thermal



Spectral evolution

2SBPL until 42s
E_b unresolved afterwards: $E_b \approx E_p$
After 120s, α rises → Eb and Ep drift apart again

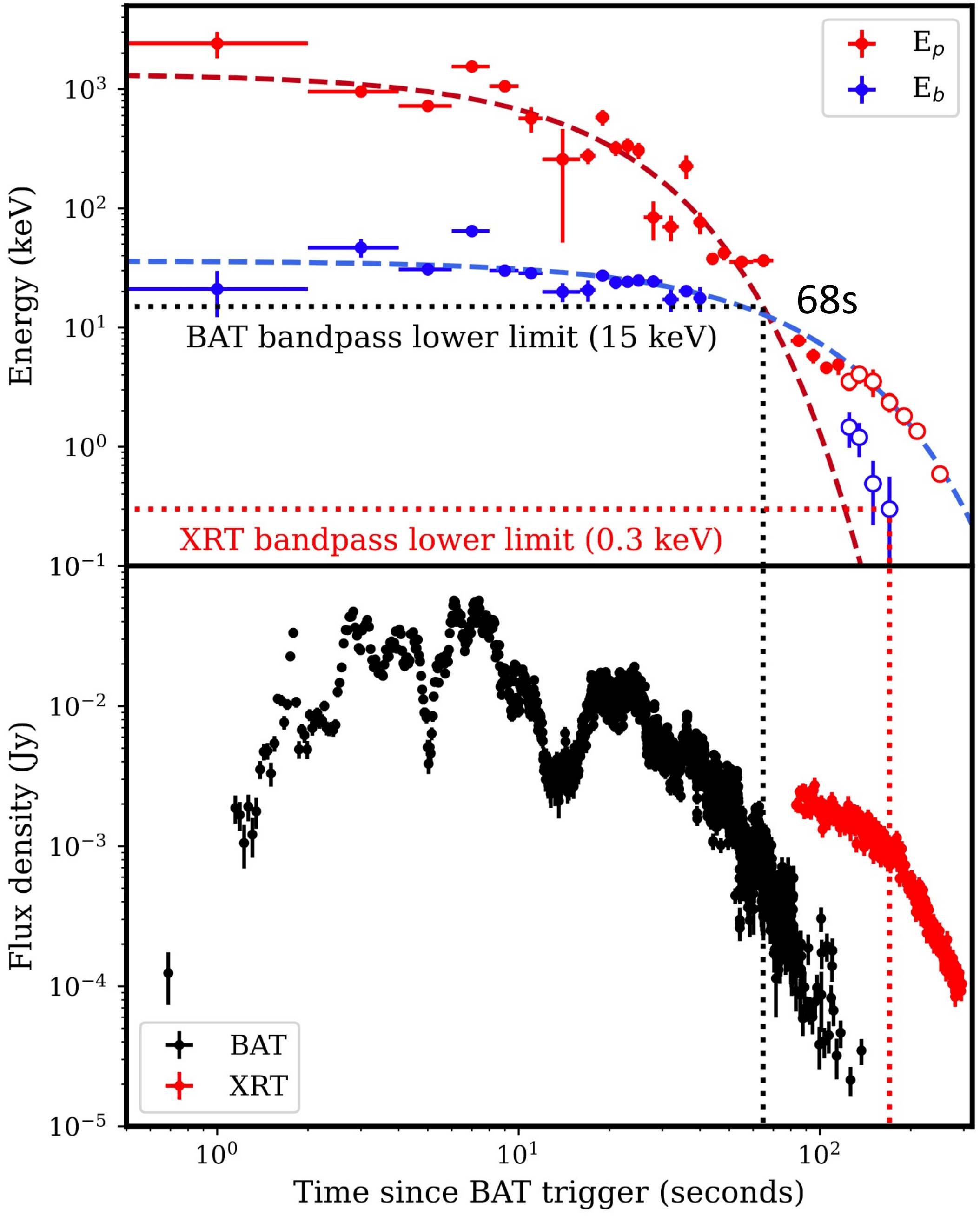


Spectral evolution

- A transition from fast to slow cooling?

« The characteristic timescale for the evolution of νc (τEb = 63.3 ± 20.2 s) and the turnover of the X-rays (τX = 66.9 ± 1.0 s) are close to the fast-to-slow cooling transition time (tc ≈ 68 s) suggesting a connection between the cooling transition and the EE duration. »

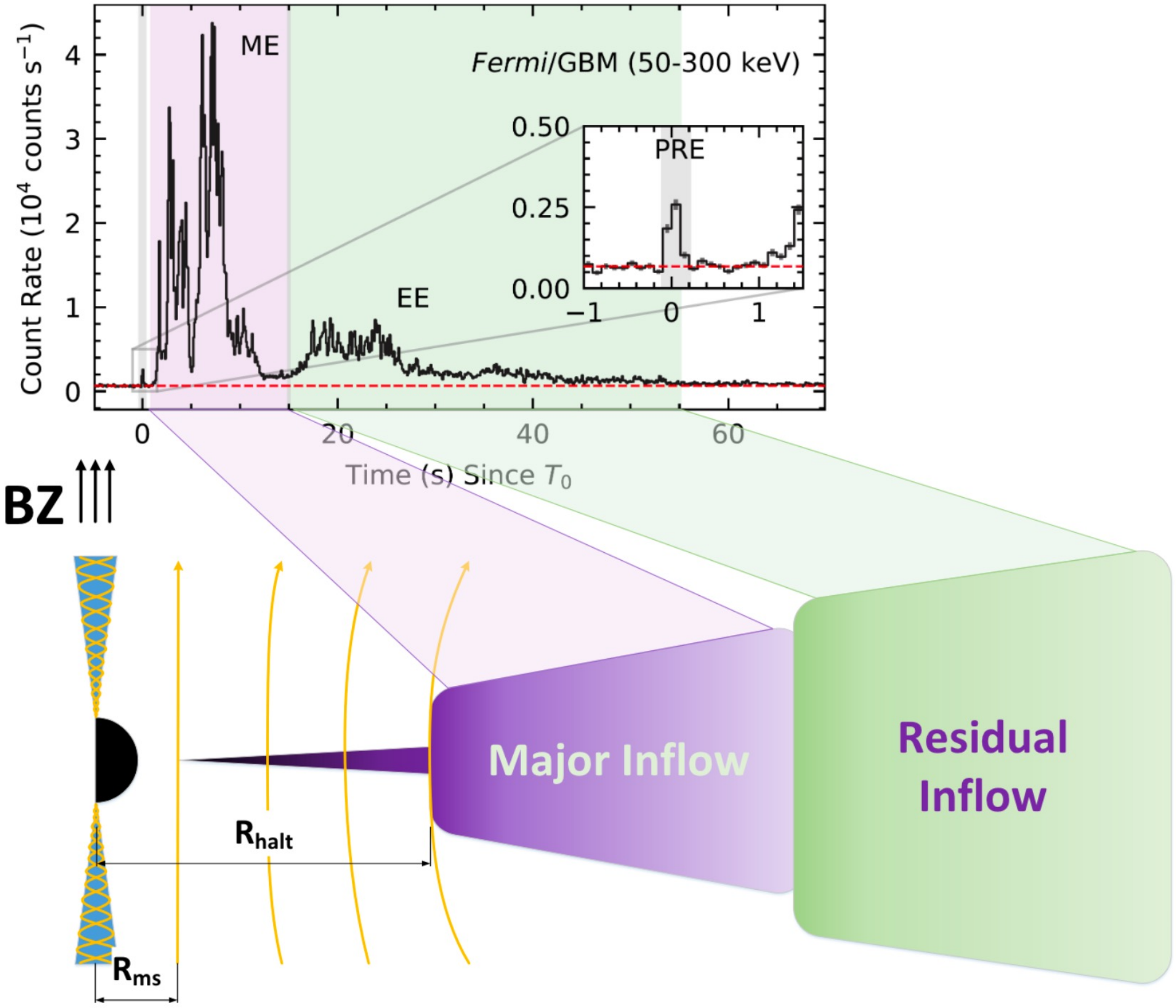
« The characteristic timescale of νm (τEp = 14.4 ± 1.14 s) is well matched to the duration of the IPC (∼ 12 s). This likely relates to the duration of the jet, which energises the shock during the IPC, keeping νm consistently high. »



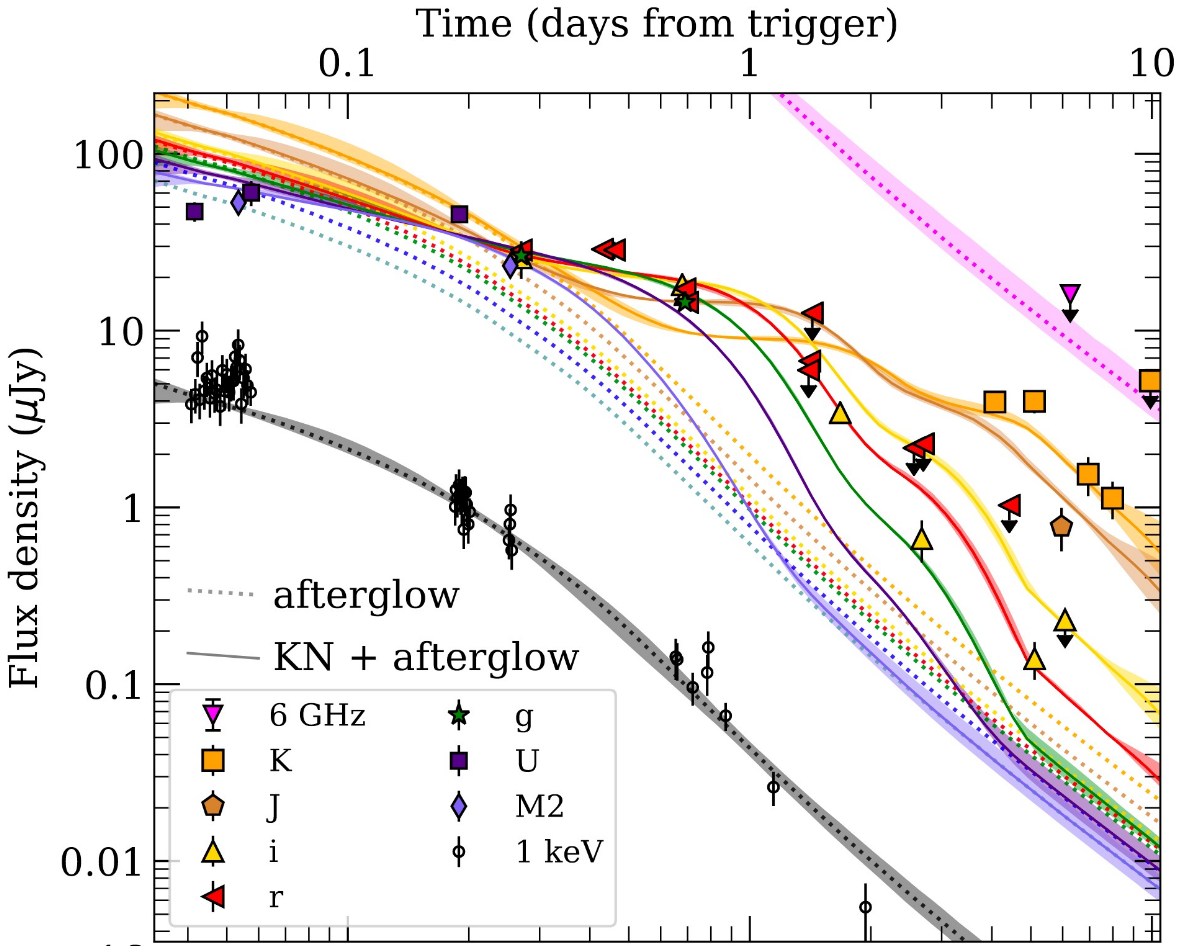
Other results from spectral analysis

- B = 20 – 300 G (similar to marginally fast-cooling collapsar GRBs, but at odds with typical GRB emitting region)
- UVOT data at 263s below synchrotron extrapolation (due to self-absorption?)
- EE from a magnetar remnant?

Explaining the burst shape with strong magnetic fields



Afterglow fitting



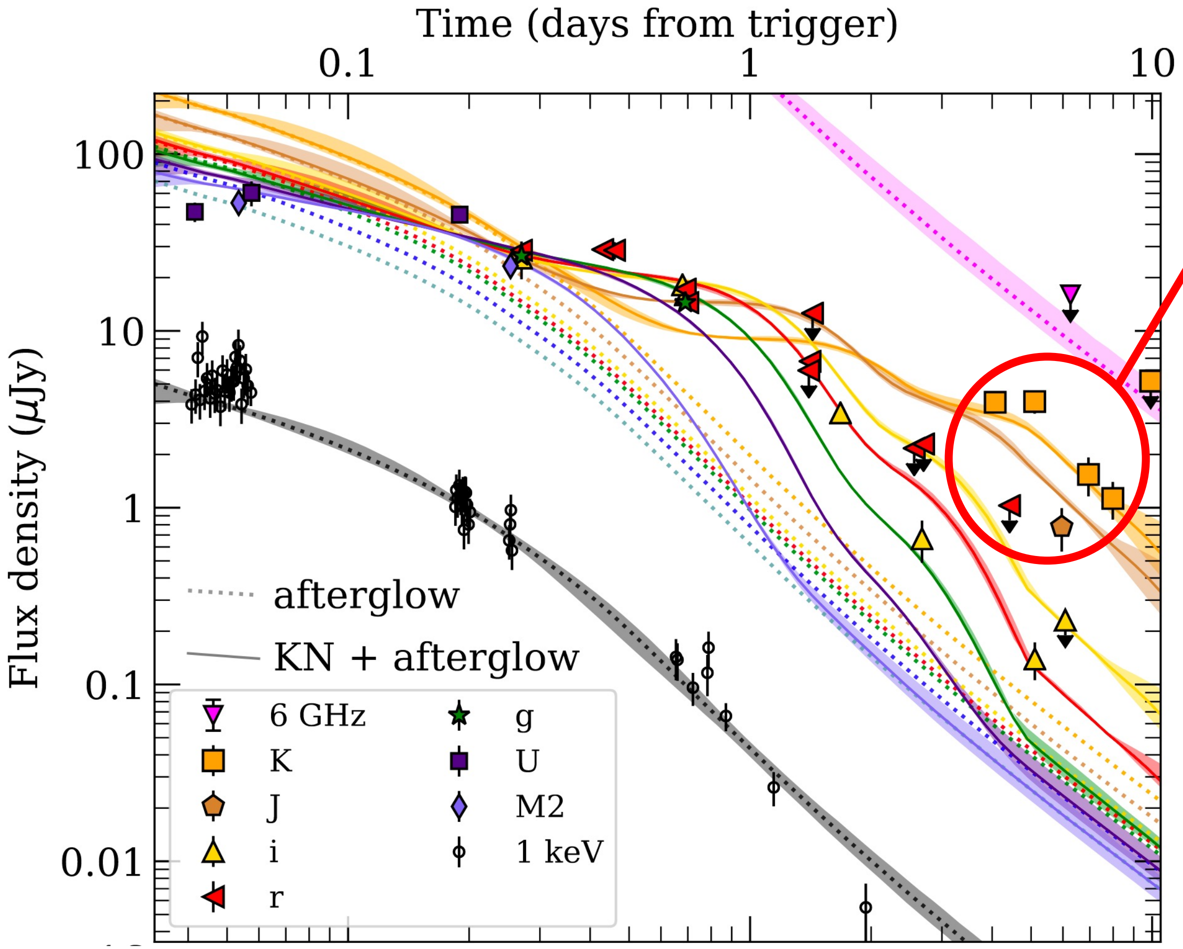
Radio + X-ray + t < 0.1day UV/optical/NIR data
➔ Afterglow fit

Table 3 Afterglow Modeling Parameters

Parameter	Median	Units
$\log(E_{\mathrm{K,iso}})$	$52.6^{+0.96}_{-1.01}$	erg
Γ_0	$165.7^{+156.9}_{-96.6}$	
p	$2.015^{+0.009}_{-0.004}$	
ι	$1.09^{+1.03}_{-0.74}$	deg
$\log(n)$	$0.065^{+1.421}_{-2.281}$	cm^{-3}
θ_c	$3.27^{+3.90}_{-2.29}$	deg
$\log(\varepsilon_e)$	$-1.40^{+0.66}_{-1.04}$	
$\log(\epsilon_B)$	$-3.64^{+1.34}_{-1.29}$	

Interestingly very similar to AT2017gfo!

Afterglow fitting



3.8mag excess

Radio + X-ray + t < 0.1day UV/optical/NIR data

➔ Afterglow fit

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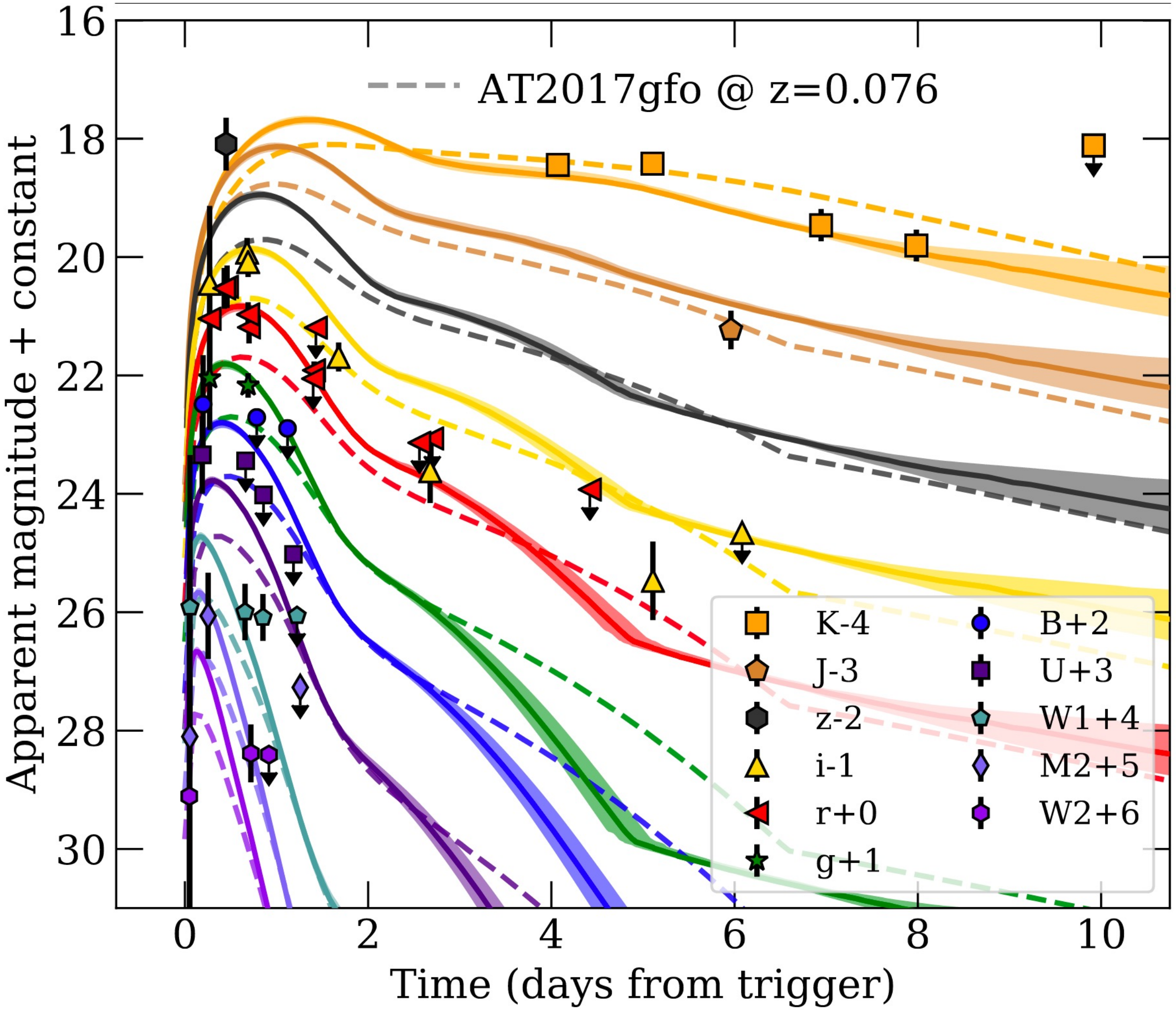
Kilonova modelling



- Substract afterglow prediction
- 3-zones KN model
- $M_{ej} = 0.04\ M_{sun}$
  - $0.03\ M_{sun}$ red ($v \approx 0.3c$) → dynamical tides
  - $0.01\ M_{sun}$ purple ($v \approx 0.1c$) → disc wind
  - $\lesssim 0.01\ M_{sun}$ blue ($v \approx 0.25c$) → dynamical shocks, winds from long-lived magnetar, disk wind with high neutrino irradiation. Effective at t < 1 day

Consistent with $1.4M_{sun} + 1.3M_{sun}$ system, but at t < 1 day, may require late GRB jet heating

A lGRB with a kilonova??

- Very good kilonova fit
- Exponential decline in X-rays at a few hundred seconds: notable feature of EE-SGRBs
- 4-13ms spectral lag between soft & hard BAT bands more consistent with sGRB (contradict the lGRB lag-luminosity relation)
- Galactic mass & SFR more consistent with sGRB hosts
- Source offset + no stellar component
- Test of the possibility of a Ni-powered event, but i-band upper limit rules out classical scenarios

So why an extended emission?

- Relativistic wind imparted by a magnetar remnant?
- NSBH system? (but hard to have enough blue ejecta at early times)
- Asymmetric BNS? (same issue)

Conclusions

- BNS merger rate from sGRBs may underestimate the true population
- $\gtrsim$ 10% of lGRBs from BNS mergers?
- With O4 sensitivity, SNR_{LIGO} = 7.4 ; O5: SNR_{LIGO} = 13.7