

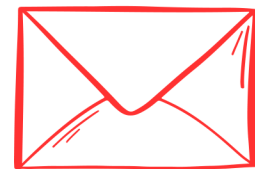
# Deciphering the unusual stellar progenitor of GRB 210704A

MNRAS, Volume 522, Issue 4, July 2023, Pages 5204–5216

## Rosa L. Becerra

Postdoc

Univerità degli Studi Tor Vergata, Roma  
([rosa.becerra@roma2.infn.it](mailto:rosa.becerra@roma2.infn.it))



Seventeenth Marcel Grossmann Meeting  
Pescara, Italy 07–12 July



TOR VERGATA  
UNIVERSITÀ DEGLI STUDI DI ROMA



Funded by  
the European Union



European Research Council  
Established by the European Commission

# Origin of GRB 210704A:

## Duration $T_{90}$

**Table 1.** Duration  $T_{90}$  reported by different facilities for GRB 210704A

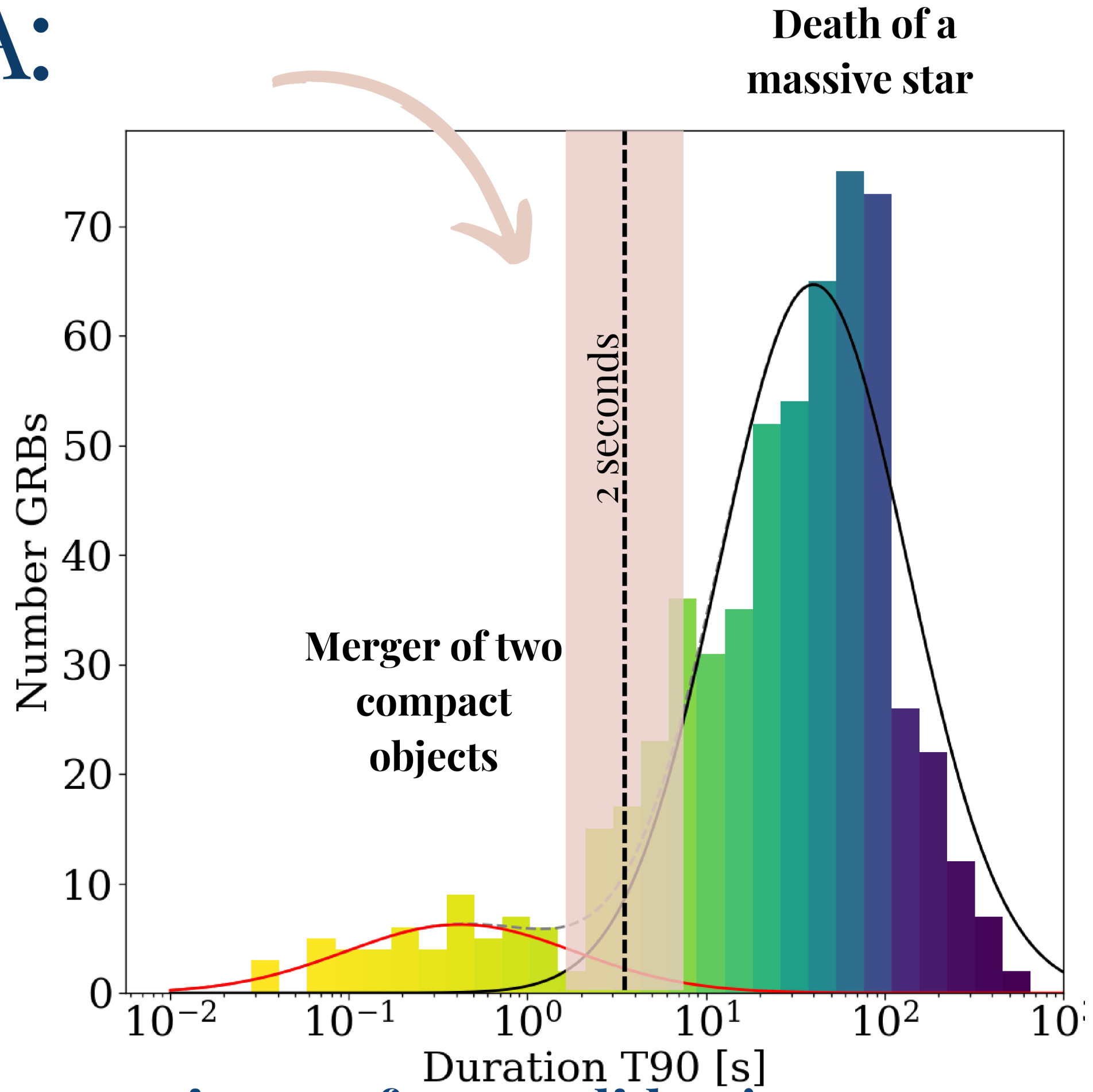
Instrument	$T_{90}$ [s]	Energy [keV]	Reference
<i>AGILE/MCAL</i>	1.06	400-100000	1
<i>AstroSat/CZTI</i>	$1.0 \pm 0.4$	20-200	2
<i>Fermi/GBM</i>	4.7	50-300	3
<i>Konus-Wind</i>	4.5	20-4000	4
<i>INTEGRAL/SPI-ACS</i>	$3.5 \pm 0.7$	80-1000	5



Short? Long?

We are interested in SGRBs...

...GRB 210704A is a perfect candidate!



# GRB 210704A: Ambiguous nature

## Motivation and interest

### GCNs:

- Possible association with a cluster of galaxies
- Noisy spectroscopic redshift  $z=2.34$ .

Multifrequency observations  
to study the evolution.

### Form part of the LGRB with a KN associated?

- GRB 211211A (Troja et al. 2022, Rastinejad et al. 2022, Yang et al. 2022, etc...)
- GRB 230307A (Yang et al. 2024, Levan et al. 2024)



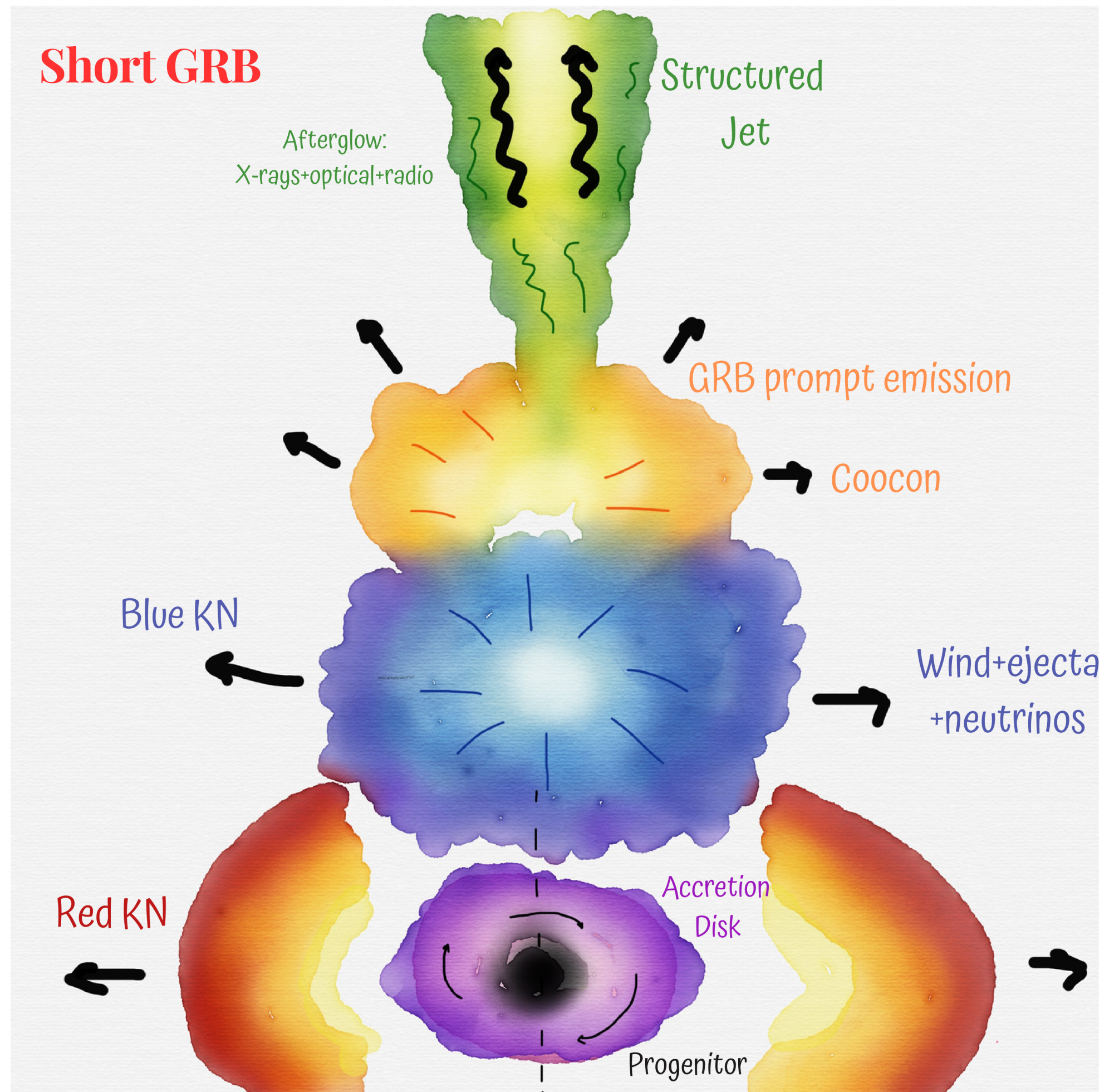


# GRB 210704A: How do we determine the progenitor?

## Short GRB

Merger of two compact objects

**Red** component associated with a lanthanide-rich outflow, and a **blue** component from a composition that failed to burn lanthanides



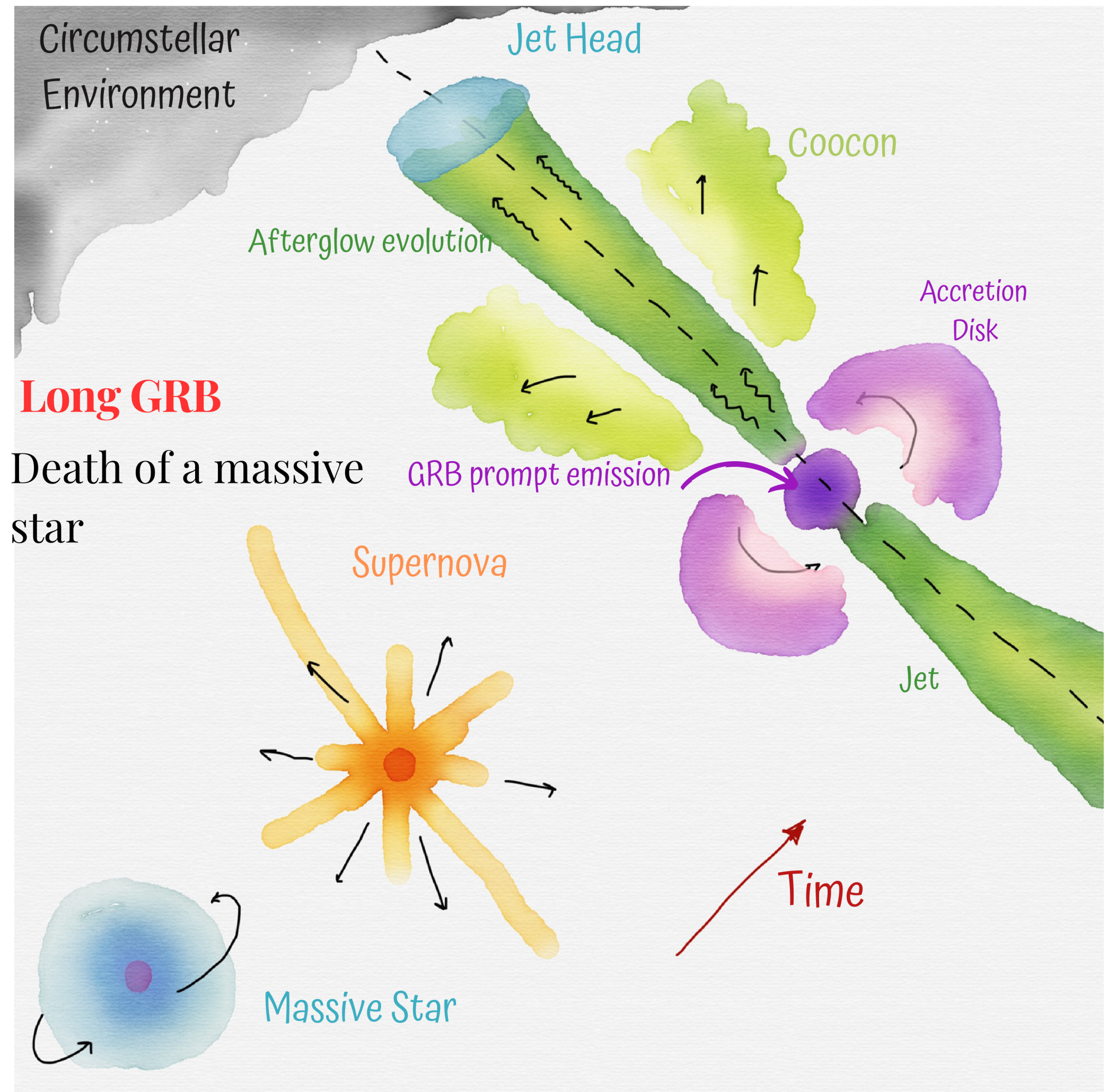


# GRB 210704A: How do we determine the progenitor?

## Long GRB

Death of a Massive Star

**After T+7 days, if the event is close, we expect to see a SN emerging**

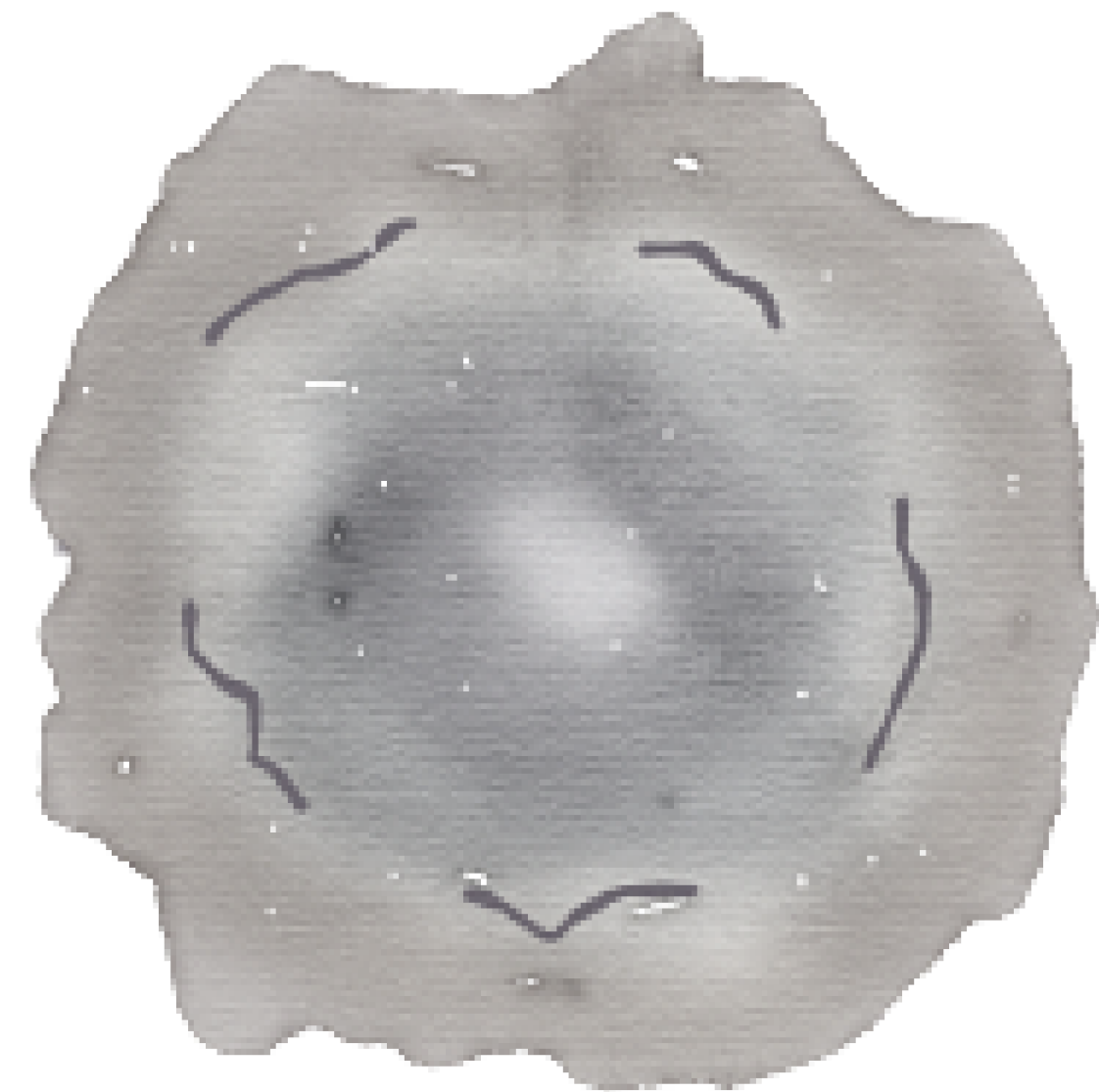




# Differences after days: optical excess

- Responsibles of the production of some metals (Ag, Eu, Th)
  - r-process (very dense environment of neutrons)
  - Toroidal+ spherical components
  - Peak at  $\sim 1$  day after the trigger
- Absolute magnitude (peak) -16

Kilonova (Short GRBs)





# Differences after days: optical excess

Powered by the nuclear decay of  
nickel into cobalt

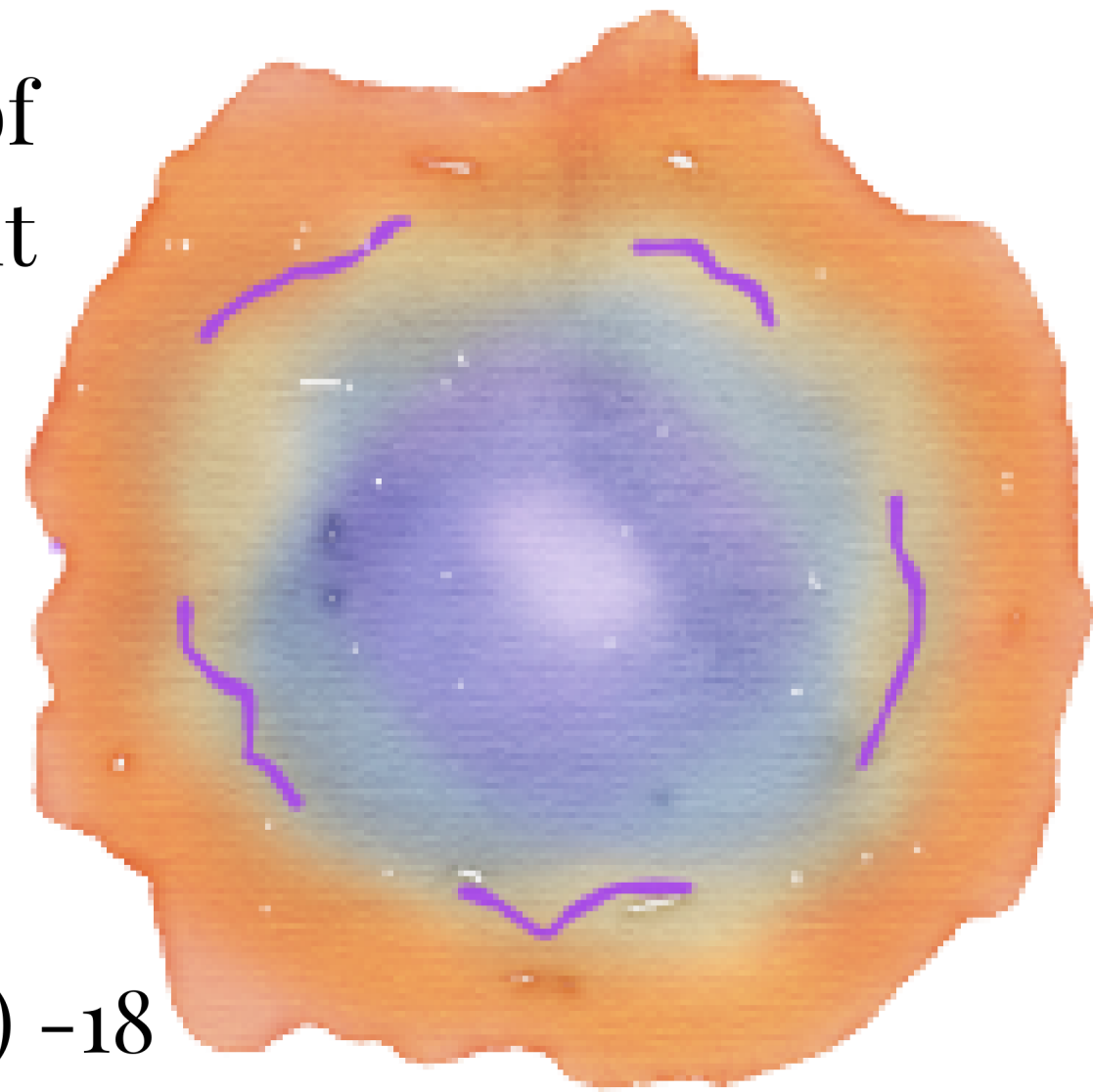
Observable after  $\sim 6$  days

Peak around 20 days

Absolute magnitude (peak)  $-18$



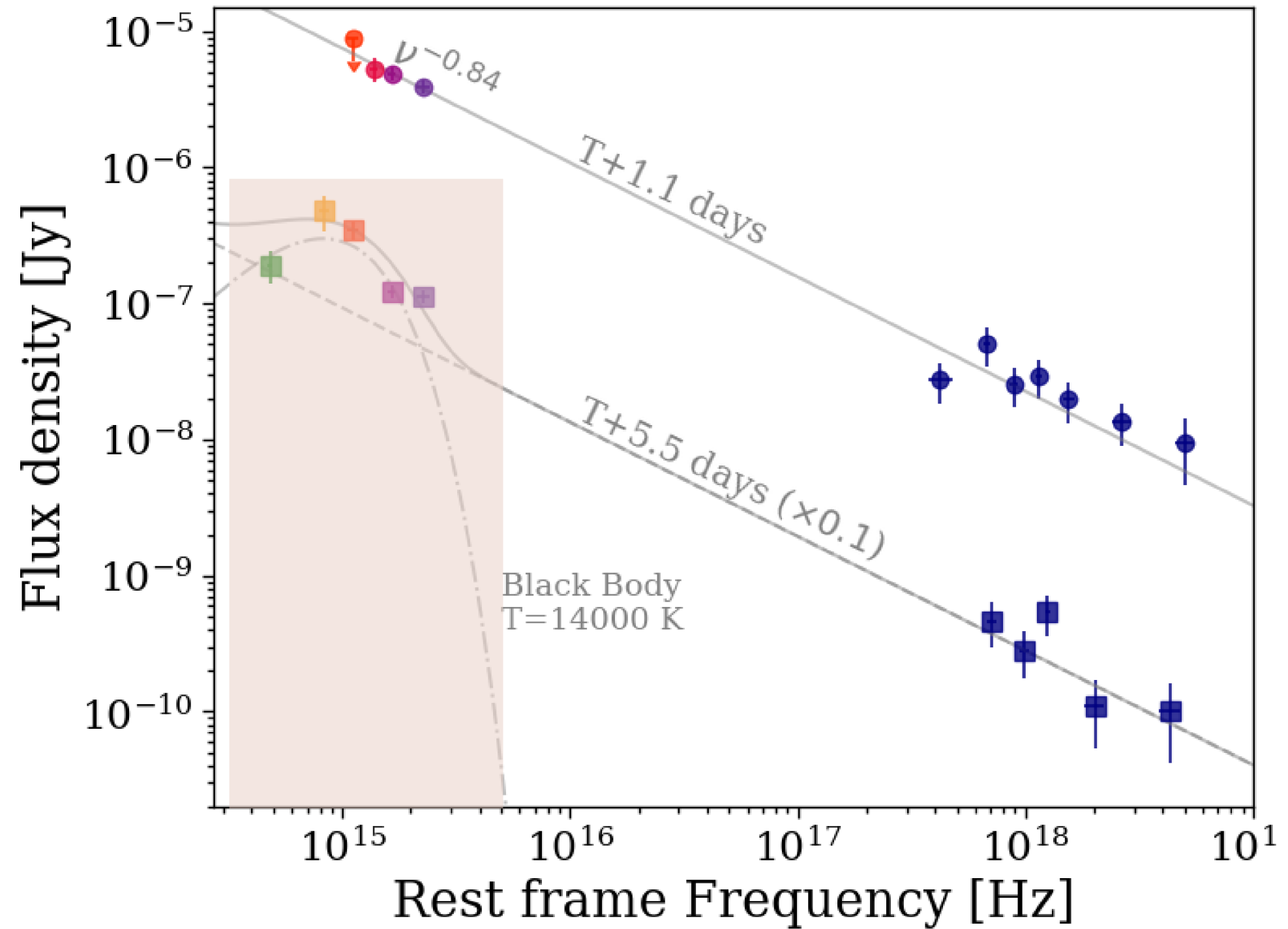
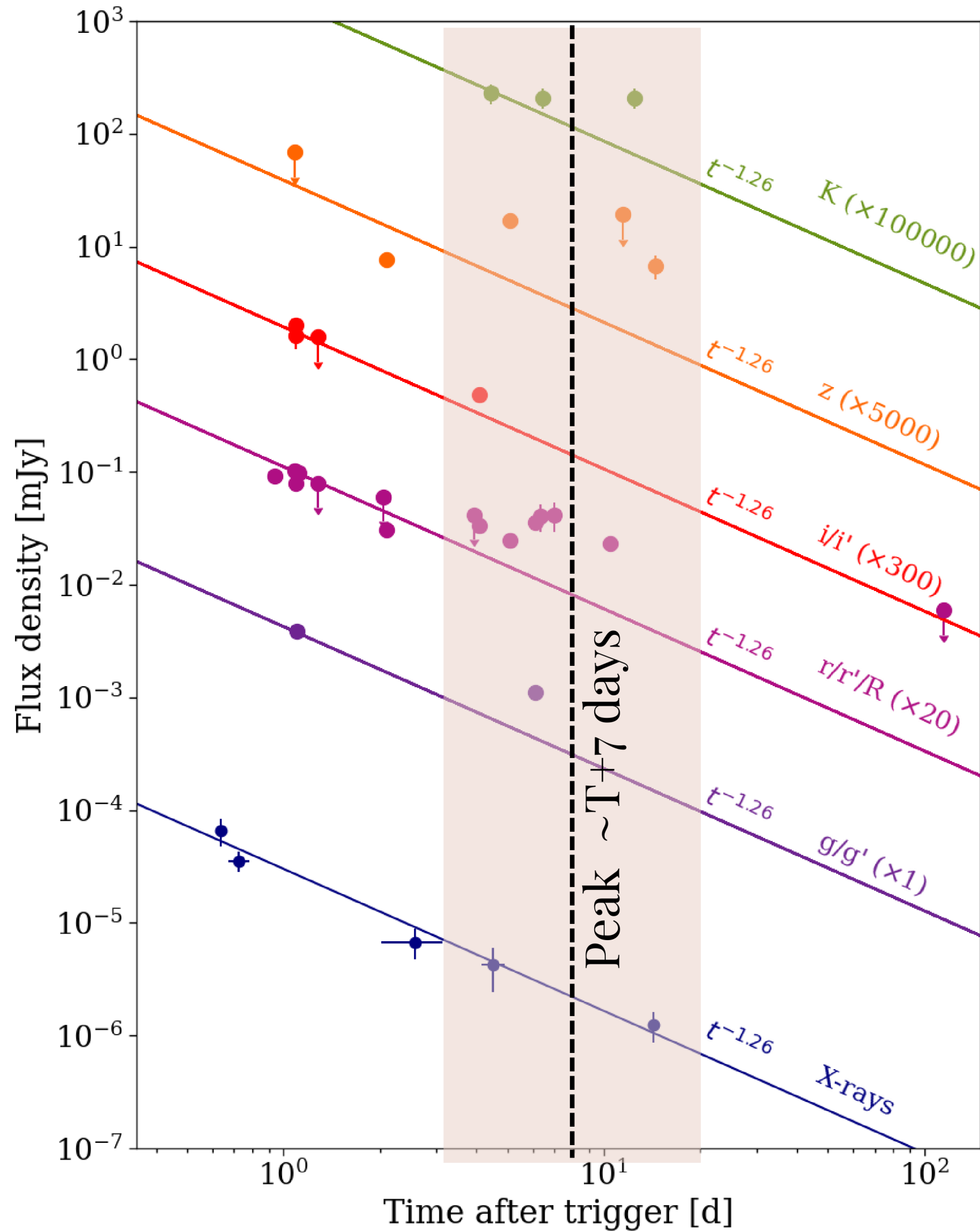
Kilonova (Short GRBs)



Supernova  
(Long GRBs)

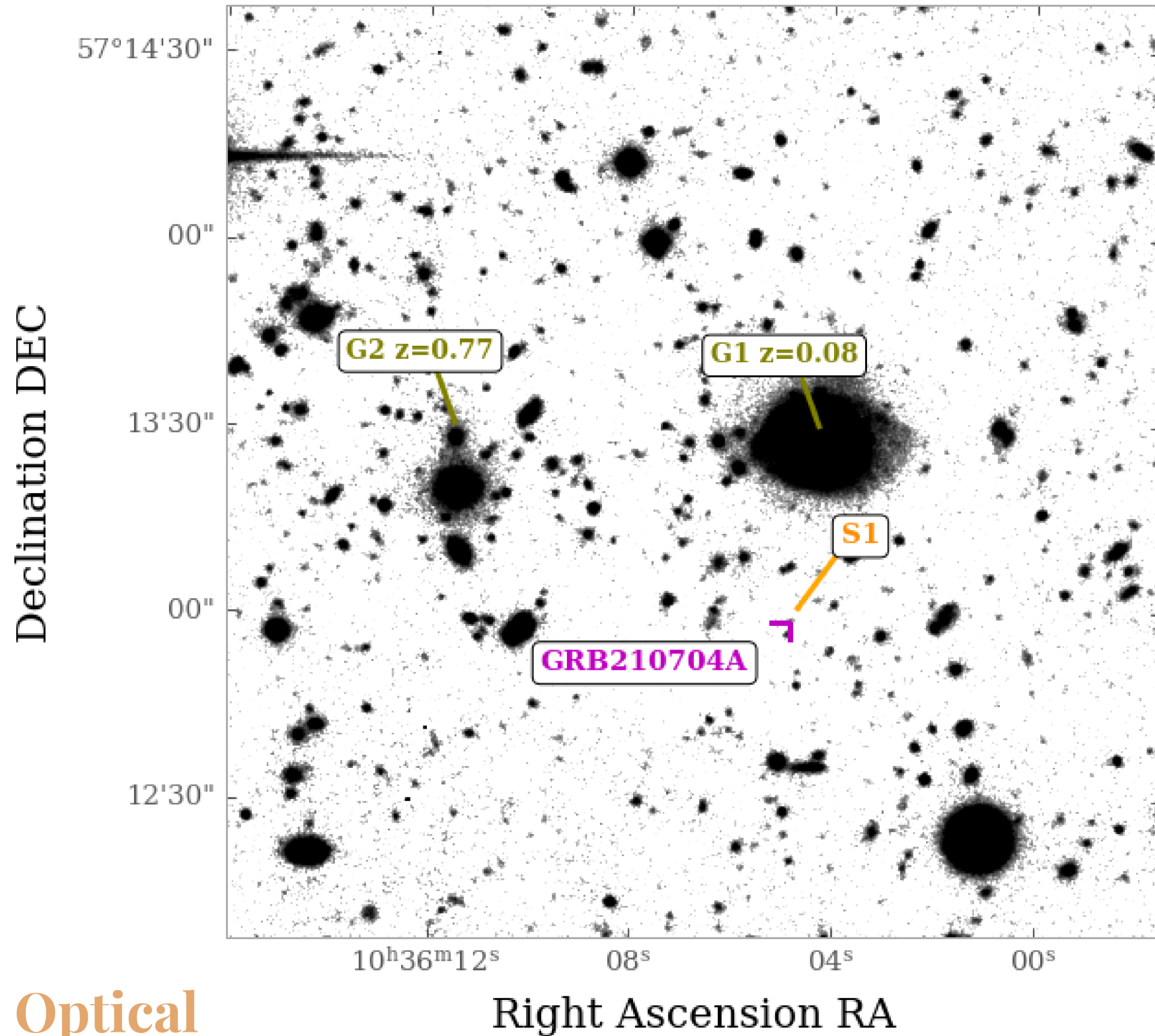
# Optical excess in GRB 210704A

Becerra et al. 2023, MNRAS, 522





# Environment and field of GRB 210704A



## Scenarios to discuss:

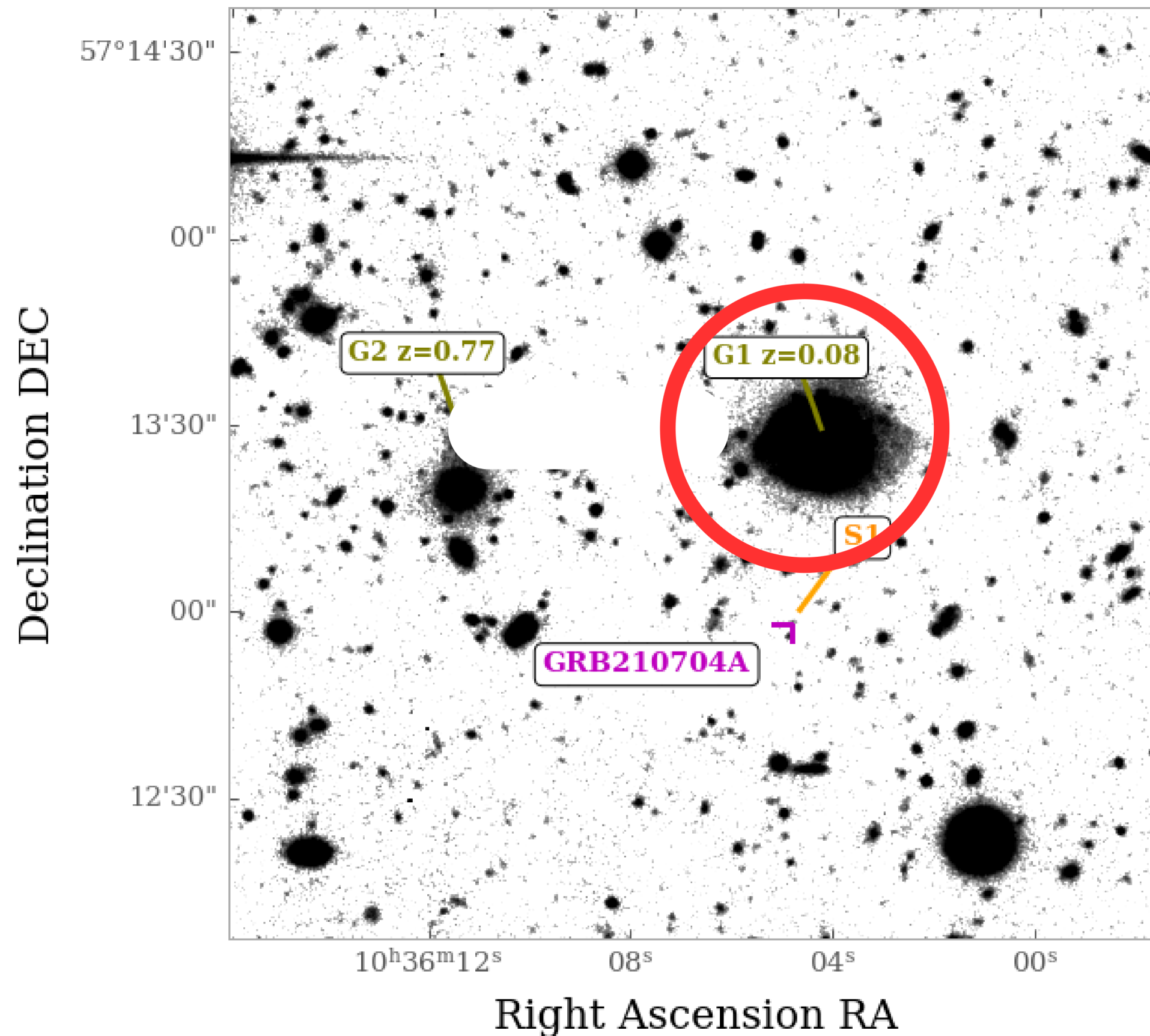
1. G1 z=0.08 (short GRB)
2. G2, cluster (short GRB)
3. S1 z=2.34 (long GRB)

# Nature of GRB 210704A: Discussion and Possible Scenarios





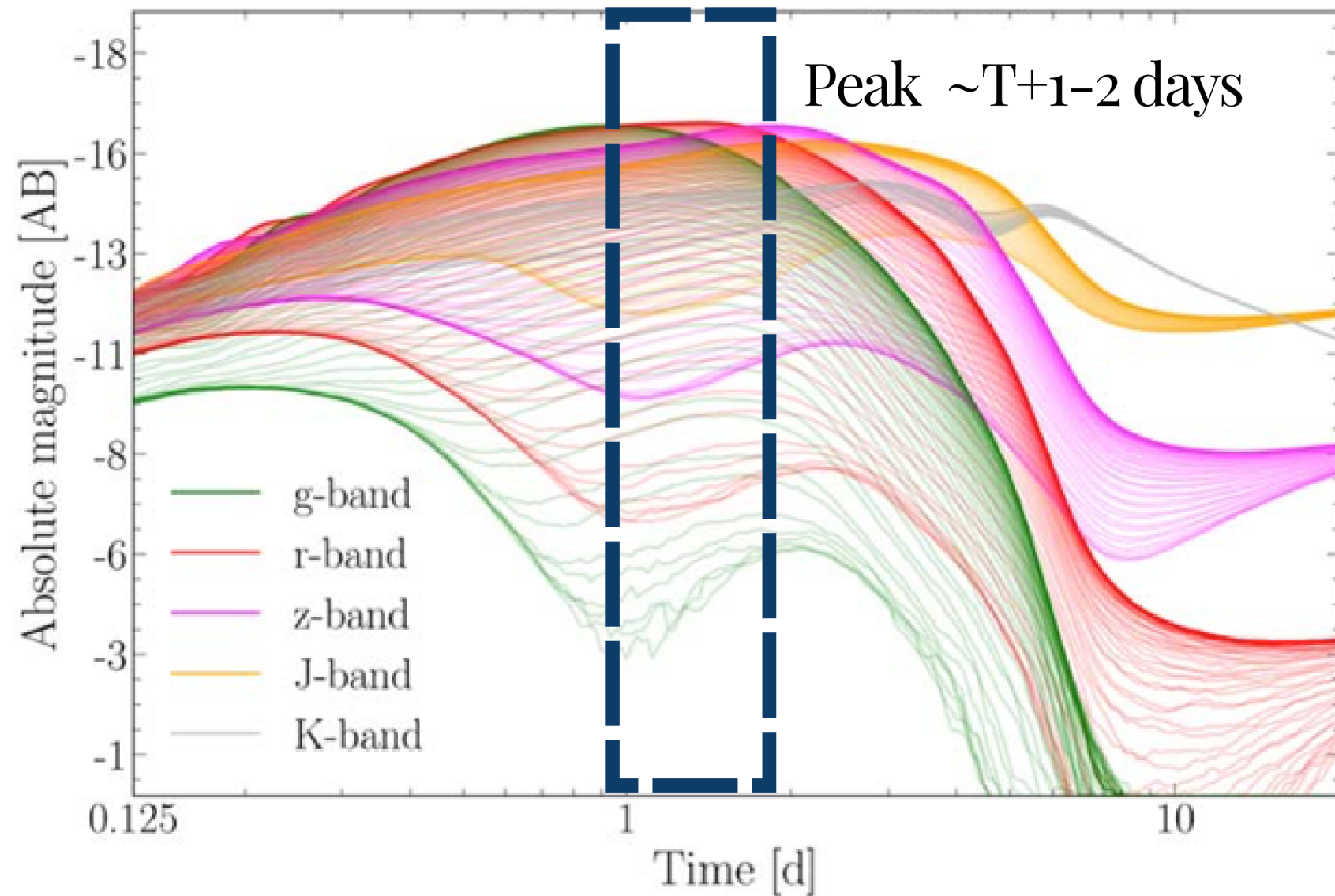
# 1. GRB 210704A at ( $z=0.08$ )



Short GRB (from  
de Amati's  
correlation)

Kilonova expected after  
some hours in UV/Optical

# 1. Exotic KN? ( $z=0.08$ )



Wollaeger et al. 2021

To explain an optical peak of about 7 days:

- Increase the mass to of order 0.1  $M_{\odot}$
- Increase the opacity-As a result, the spectral peak would shift to redder wavelengths

$$t_{\text{peak}} \approx 1.5 \text{ d} \left( \frac{M_{\text{ej}}}{0.01 M_{\odot}} \right)^{0.5} \left( \frac{\kappa}{1 \text{ cm}^2 \text{ g}^{-1}} \right)^{0.5} \left( \frac{v_{\text{ej}}}{0.1c} \right)^{-0.5}$$

Arnett (1982)



# 2. Exotic progenitor

Previous LGRB possibly associated with a galaxy cluster is

**GRB 050911**

(with  $T_{90} \sim 1$  s and a tail of  $\sim 16$  s)

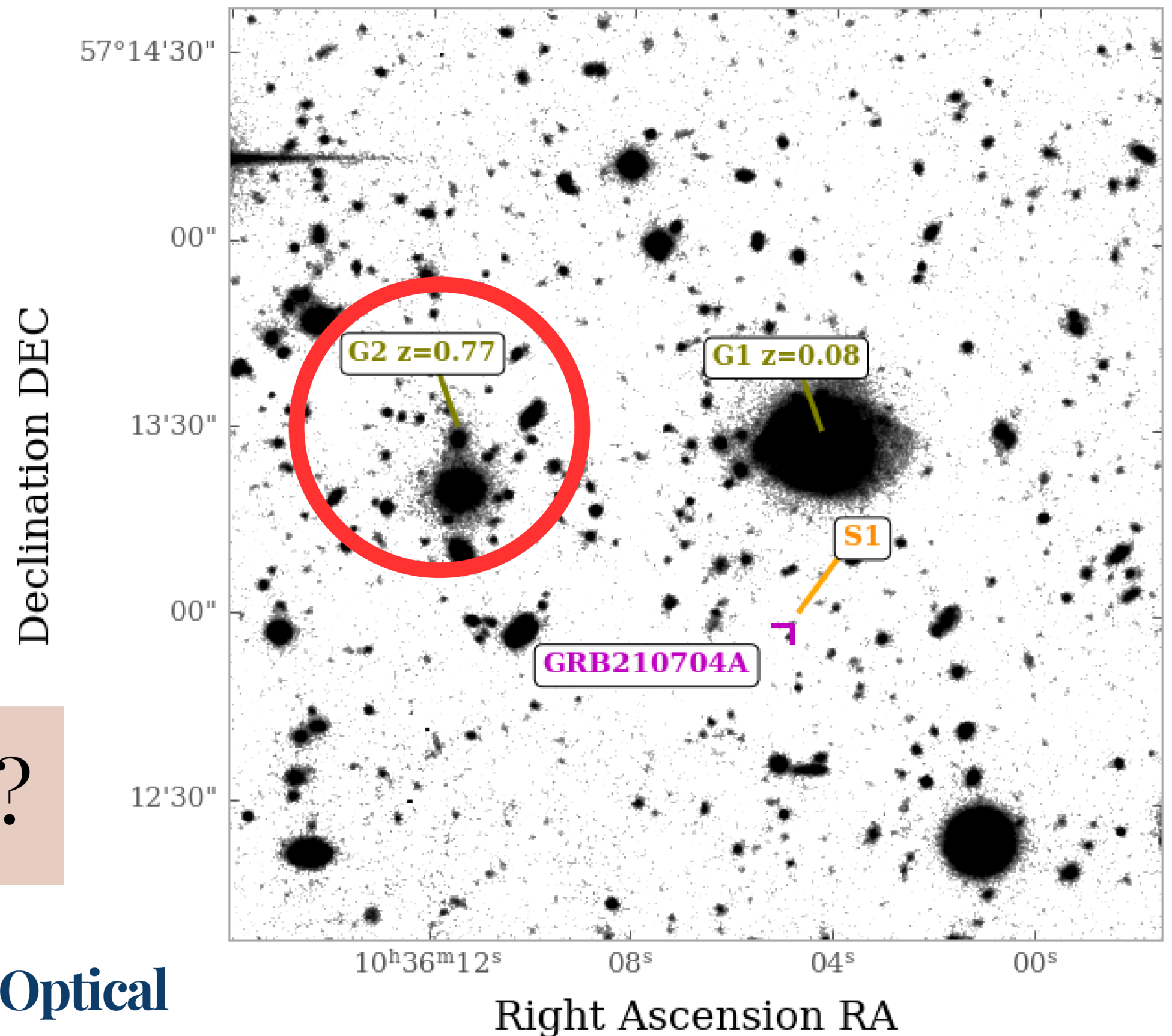
Peak time,  $T \sim 5000 - 10000$  K and

$V_{ej} = 0.02c - 0.2c$

WD-WD / NS-WD encounter?

(Rueda et al. 2018 ; Lyutikov & Toonen 2019)

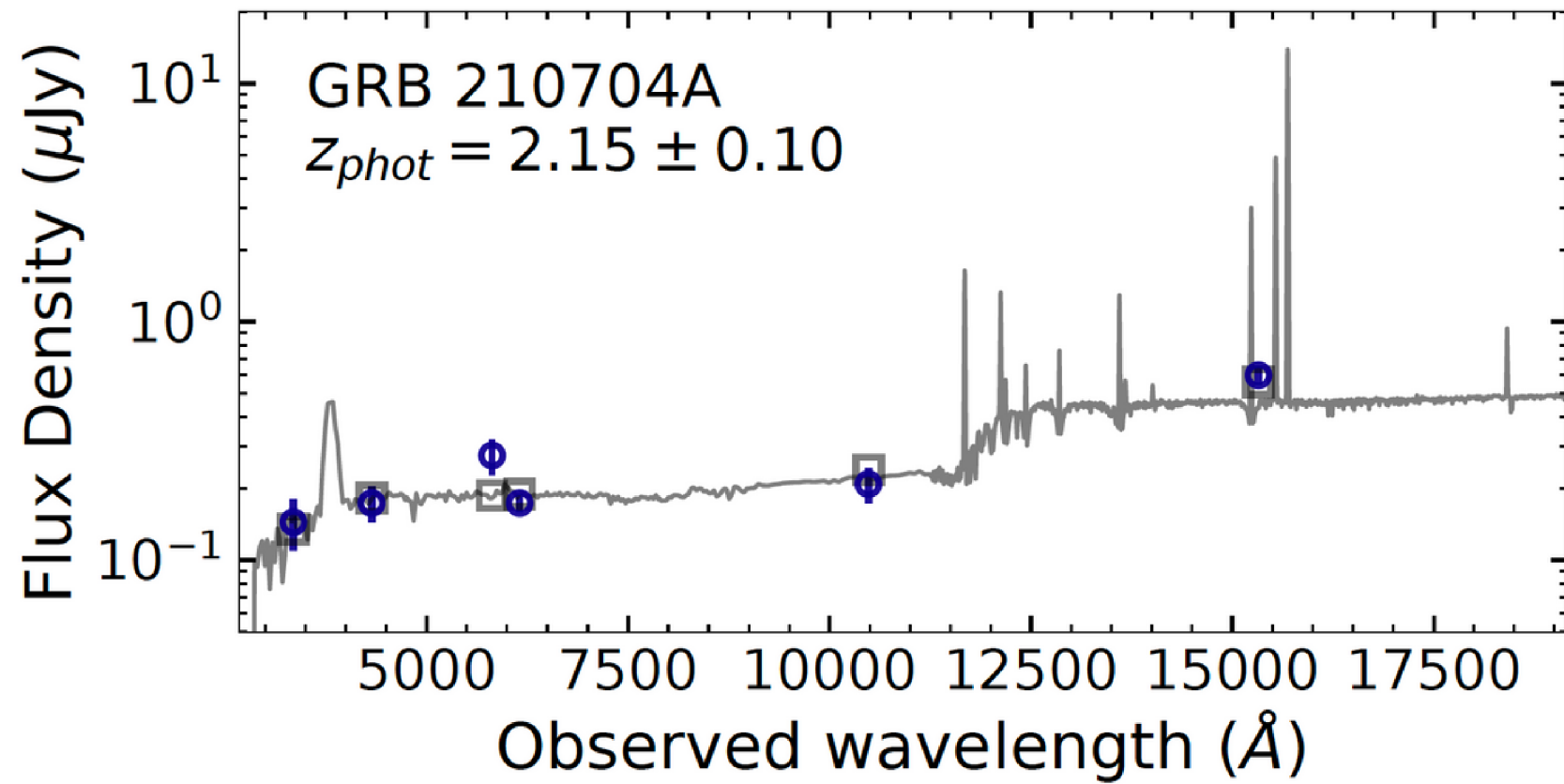
**Optical**



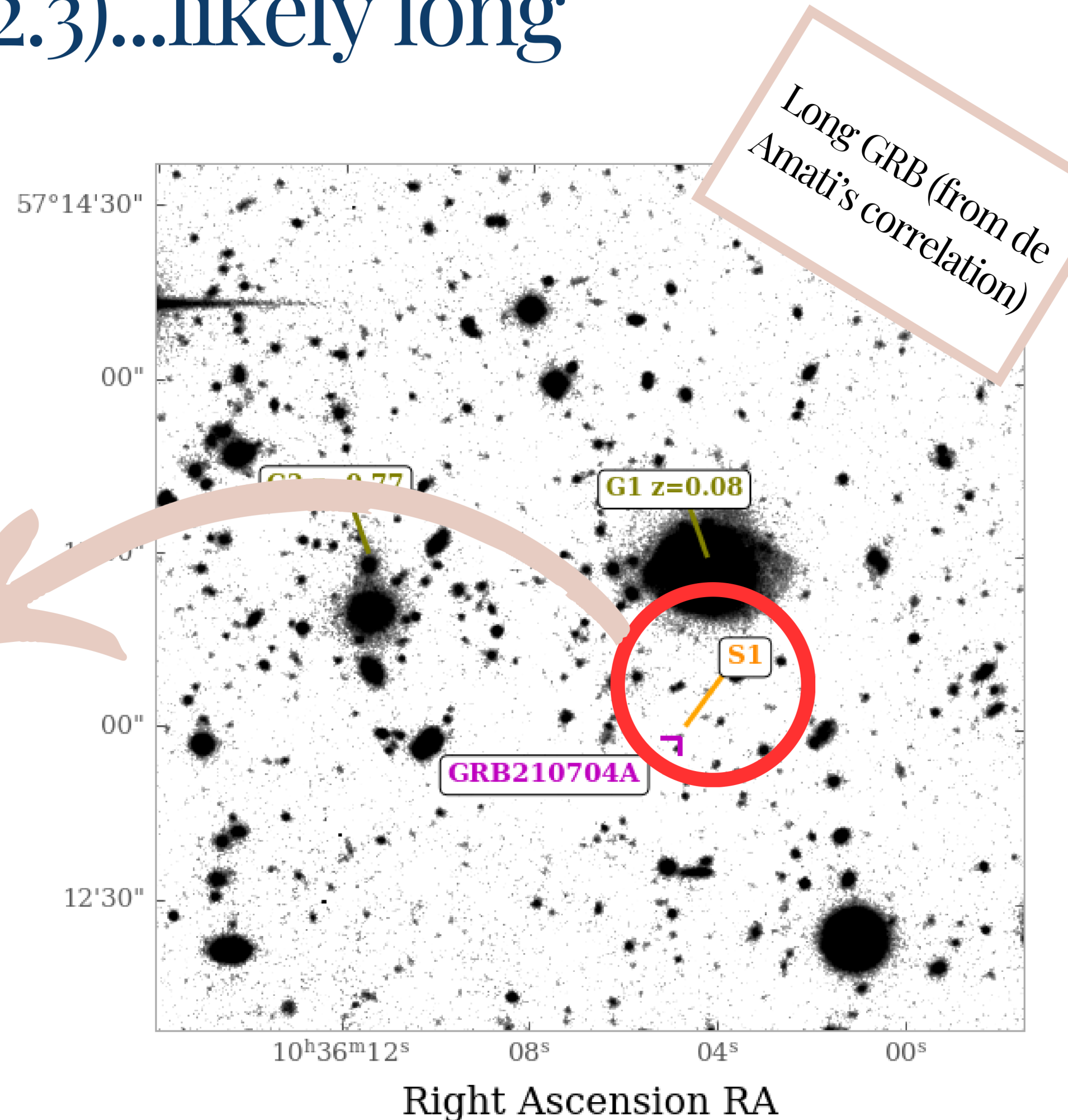
# 3. High-redshift GRB ( $z=2.3$ )..likely long

Consistent with the **afterglow redshift  $z=2.34$**   
(but very noisy)

S1 photometric redshift

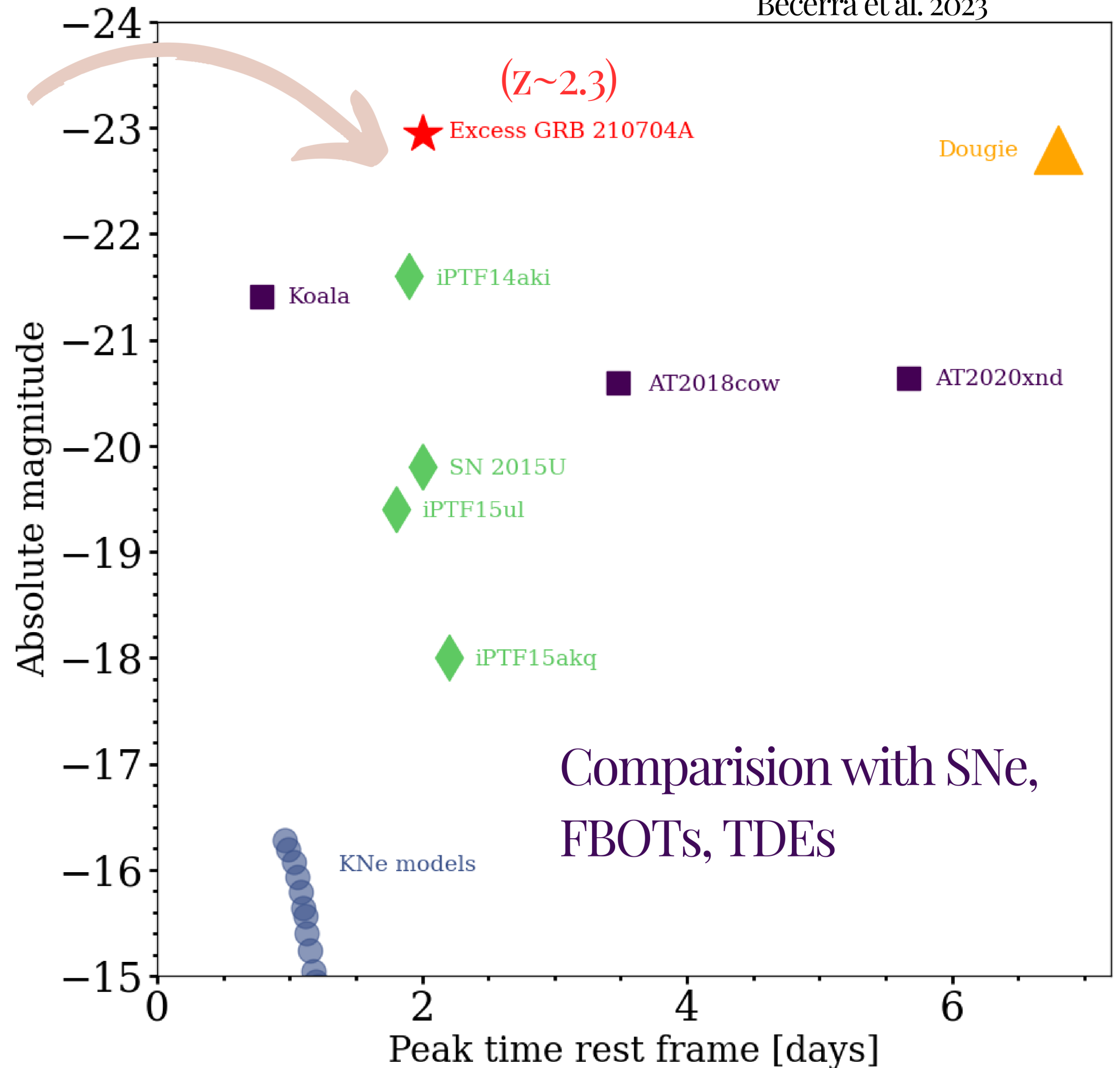


Declination DEC



# 3. The brightest SN ever?

Considering a BB component at  $z=2.3$ , this has a  $M \sim -23$ !!!!



Comparison with SNe, FBOTs, TDEs



# Conclusions

We explore three scenarios. None of them is completely satisfactory:

1. Associated to a very close galaxy?  $\longrightarrow$  New type of KN.
2. Cluster of galaxies?  $\longrightarrow$  Exotic transient WD merger?
3. Very far GRB  $\longrightarrow$  Special SN?

...this event challenges the standard  
GRB classification

A small icon of a research paper with the word "RESEARCH" written on it.

RESEARCH

**Deciphering the unusual stellar progenitor of GRB 210704A**

MNRAS, Volume 522, Issue 4, July 2023, Pages 5204–5216

# Deciphering the unusual stellar progenitor of GRB 210704A

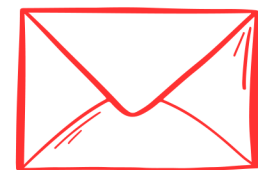
MNRAS, Volume 522, Issue 4, July 2023, Pages 5204–5216

Grazie per la vostra attenzione :)

Rosa L. Becerra

Postdoc

Univerità degli Studi Tor Vergata, Roma  
([rosa.becerra@roma2.infn.it](mailto:rosa.becerra@roma2.infn.it))



Seventeenth Marcel Grossmann Meeting  
Pescara, Italy 07–12 July



TOR VERGATA  
UNIVERSITÀ DEGLI STUDI DI ROMA



Funded by  
the European Union



European Research Council  
Established by the European Commission