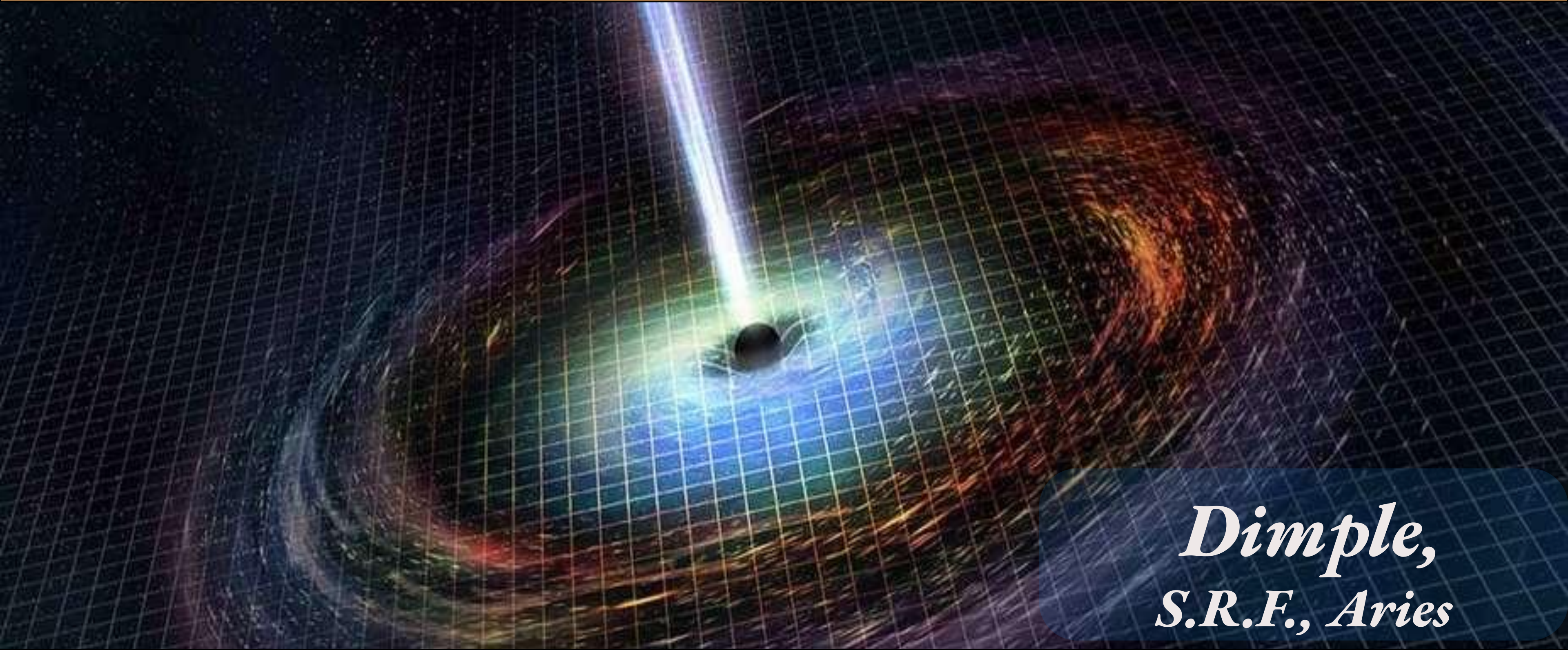
GRB 201221D: A short GRB at high redshift

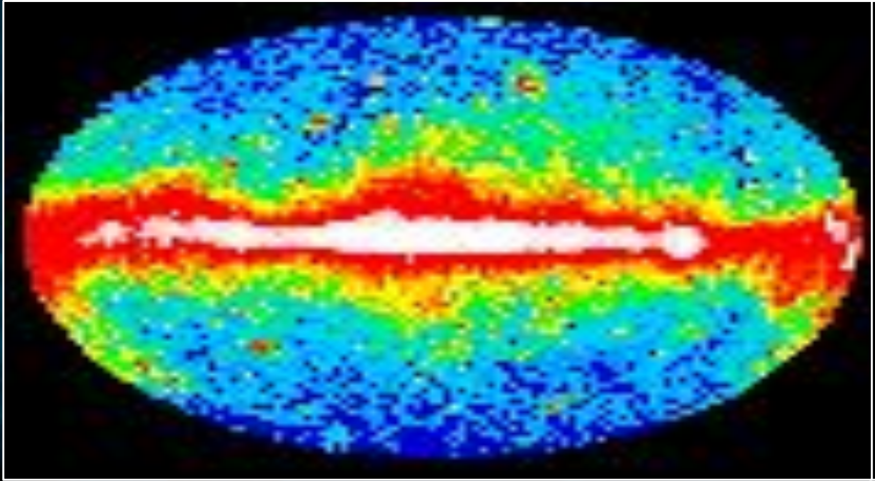


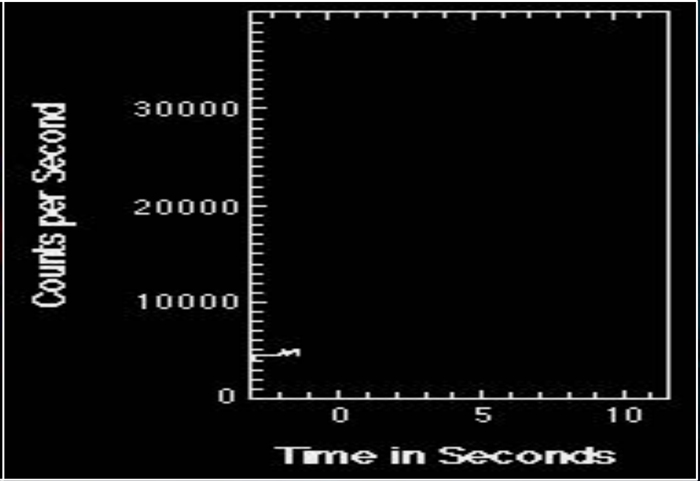
Dimple,
S.R.F., Aries

In collaboration with :
K. Misra, D. A. Kann, K. G. Arun, A. Ghosh, L. Resmi et al.

Gamma Ray Bursts: Introduction

- GRBs are the flashes of γ -rays that last from milliseconds to thousands of seconds
- Isotropic distribution over sky
- Cosmological origin (z ~ 0.008 - 9.4)
- E_{iso} ~ 10^{48}–10^{55} ergs
- Multi-wavelength phenomena (from γ-rays to radio)





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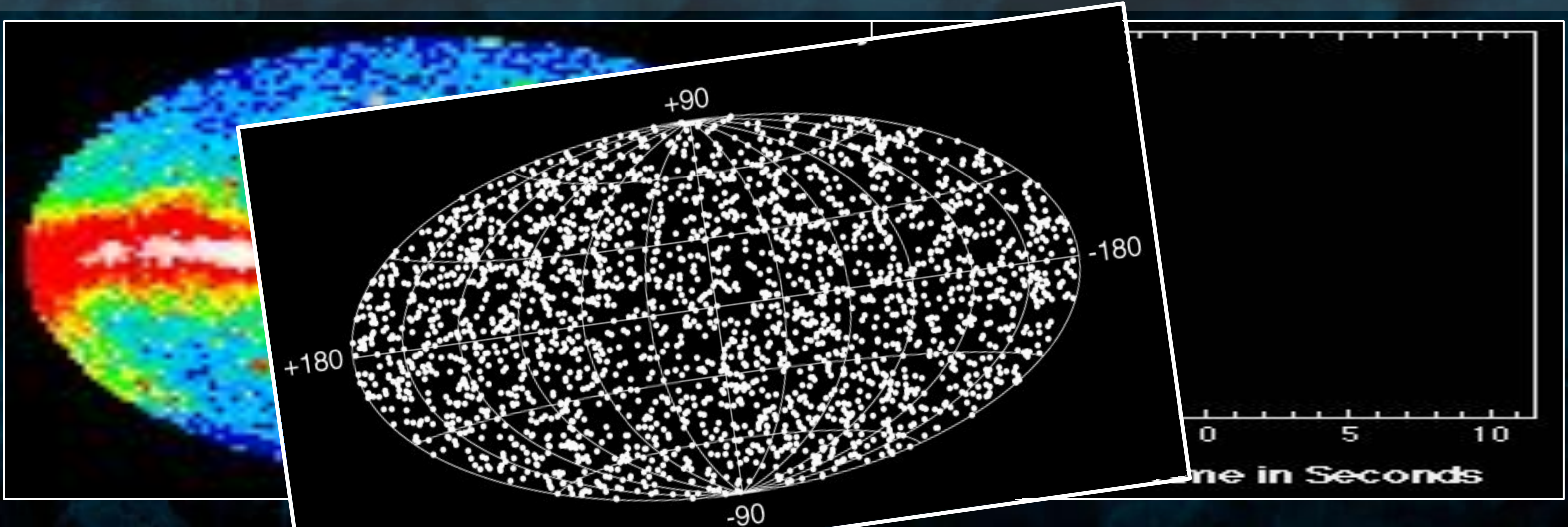


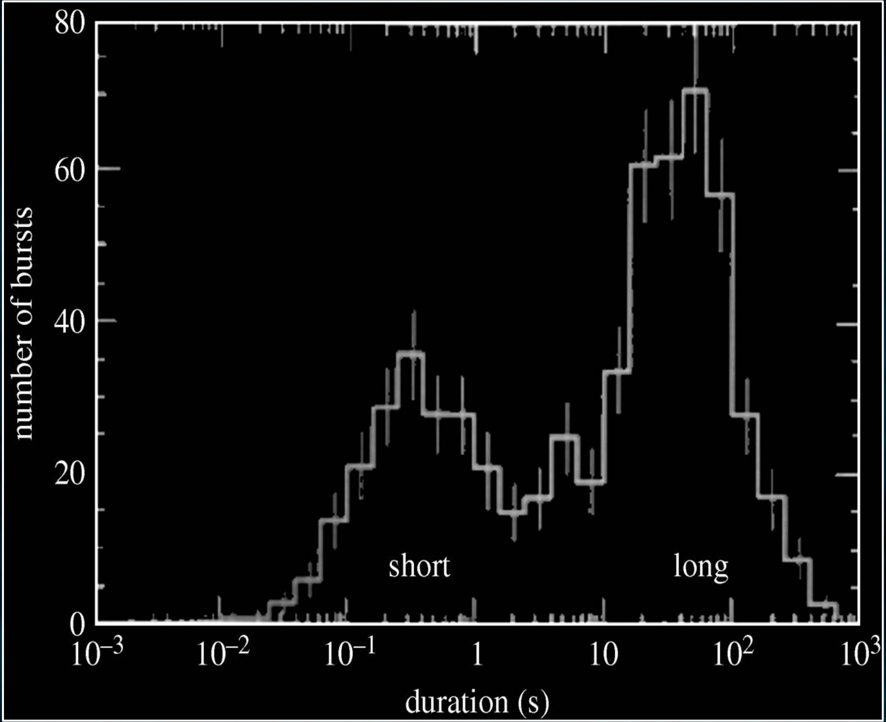
Classification: Bimodal distribution

- **Shows bimodal distribution, dividing GRBs in two classes (Briggs et al. 2002):**

1. **Short GRBs : T_{90} < 2 s,**
2. **Long GRBs : T_{90} >2 s,**

Where,

T_{90}: Time period in which 90% of fluence is collected by any detector



Fishman and Meegan et al. 1995

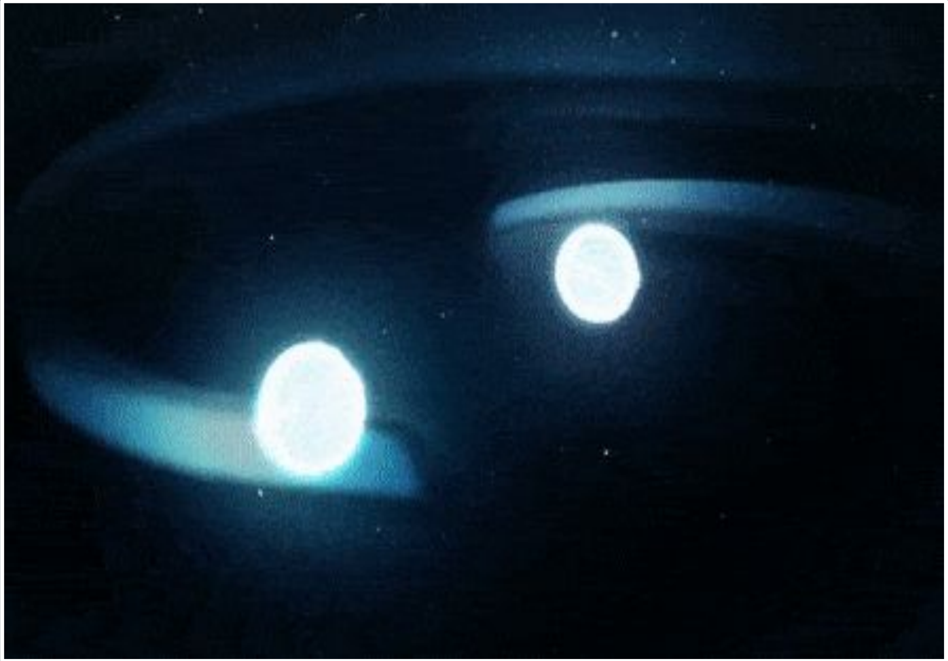
Progenitors of Short GRBs

The most prevailing hypothesis:

- Short GRBs originate from the binary compact object mergers.

Events supporting this hypothesis:

- Coincident detection of Short GRB 170817A with GW 170817 followed by kilonova AT 2017gfo
- Kilonova signatures in Short GRB 130603B



SGRBs: Afterglows

First afterglow detection of a SGRB : 2005

Total no. of SGRBs detected since then: 180

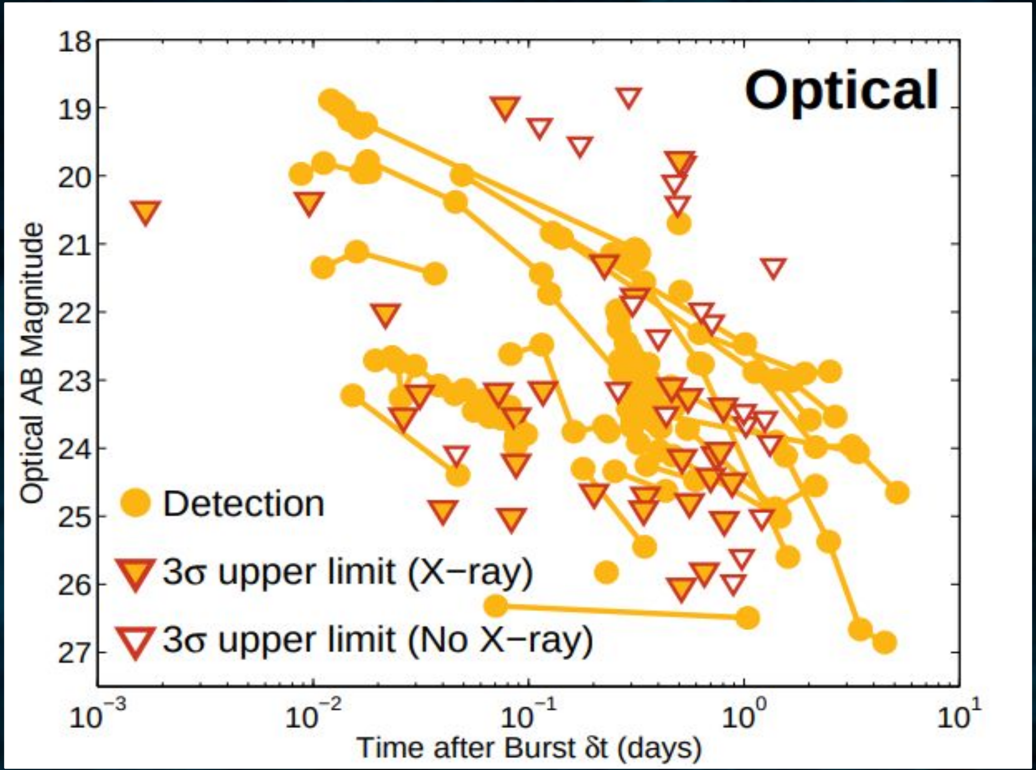
- **X-ray afterglows: 59 %**
- **Optical afterglows: 28%**
- **Radio afterglows: 6%**

Unique tool to estimate the properties of GRBs and their environments:

- **Number density, Jet opening angle, energetics, and microphysical parameters.**

Possible causes of non-detections

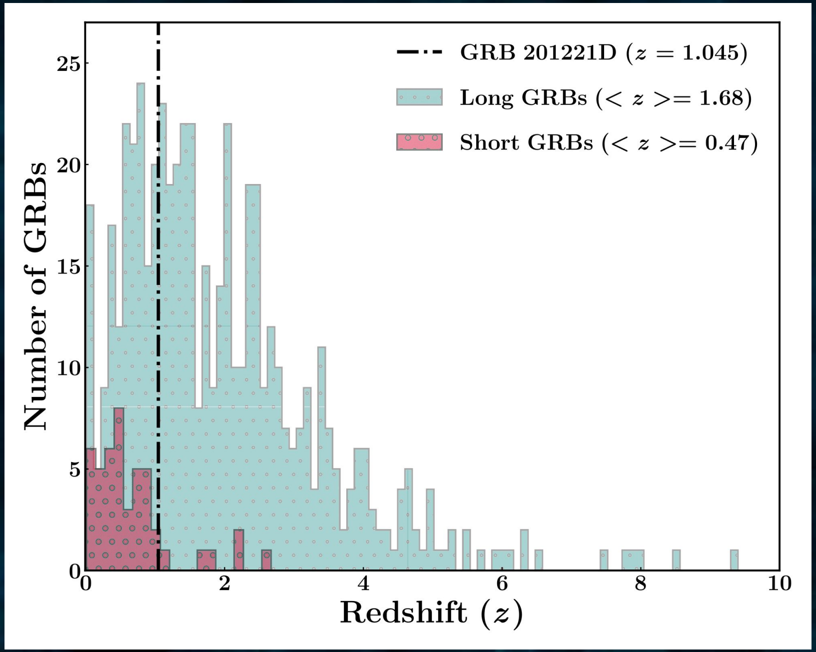
- Faint nature of SGRBs,
- Delayed precise localization from Swift,
- Crowded fields,
- High Galactic extinction sightline.

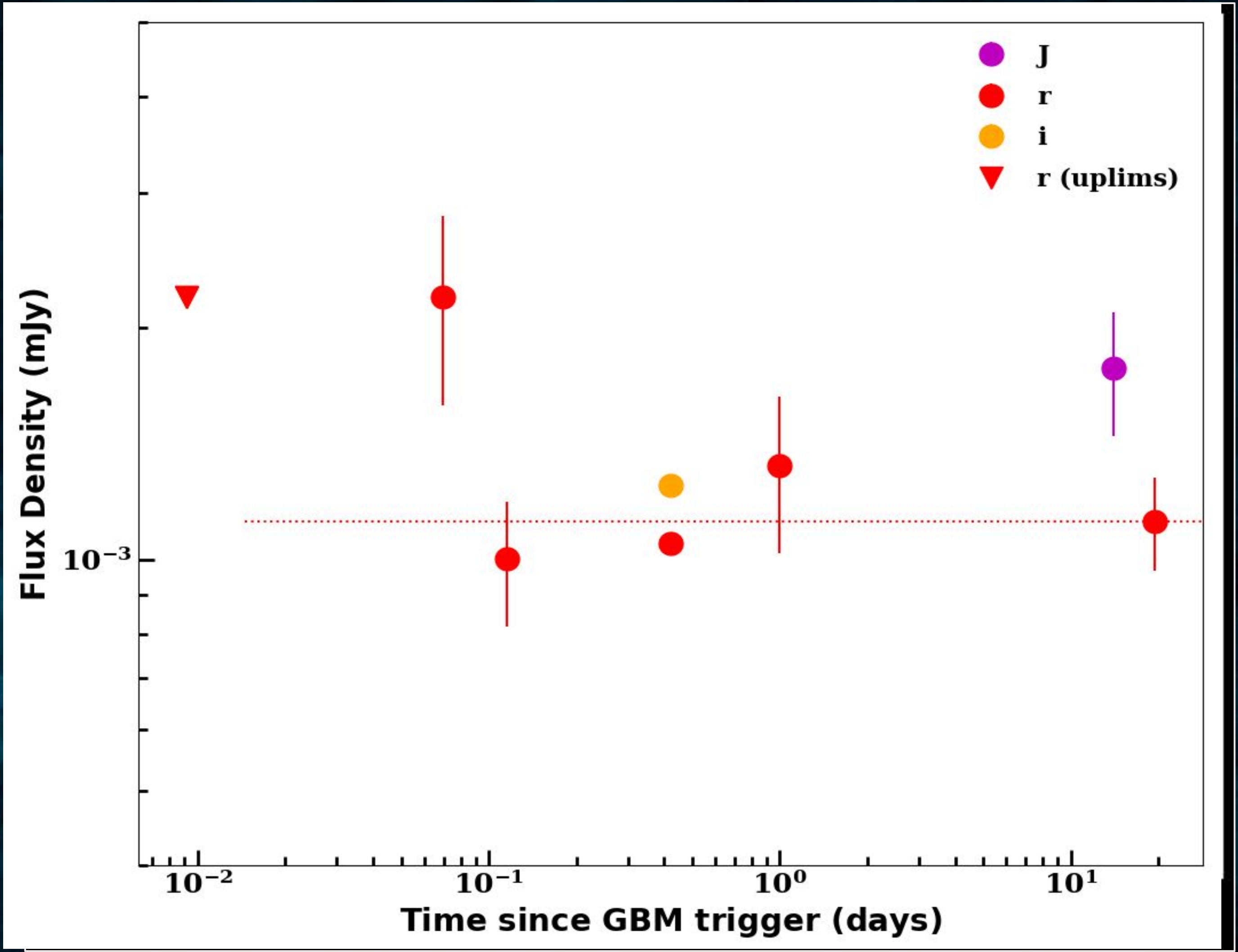


Fong et al. 2015

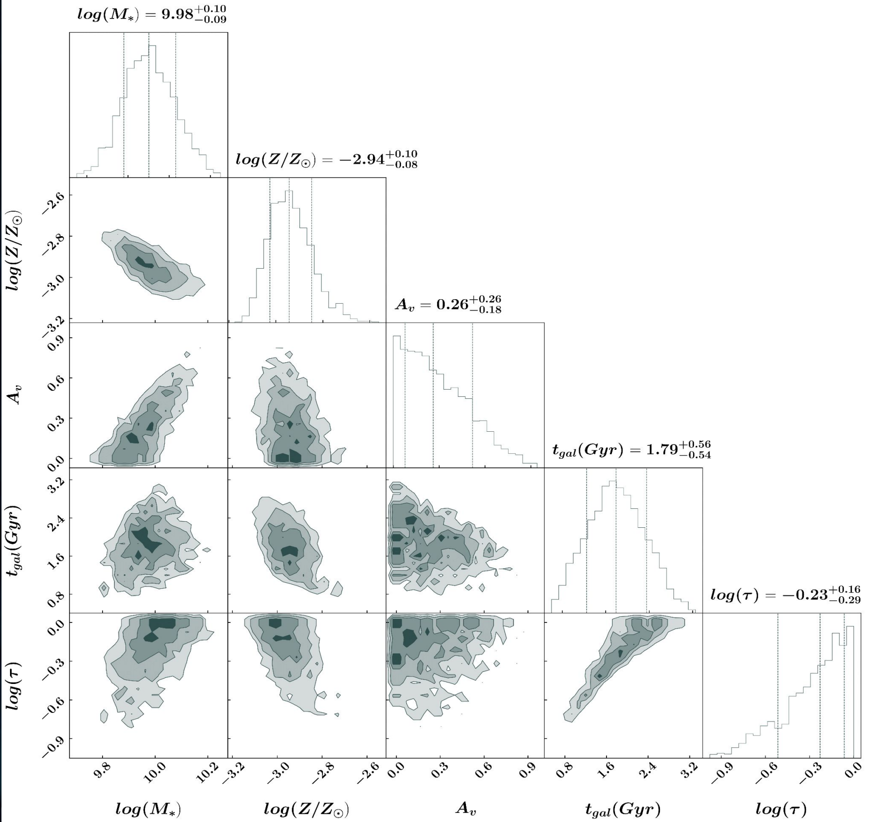
GRB 201221D: A high redshift SGRB

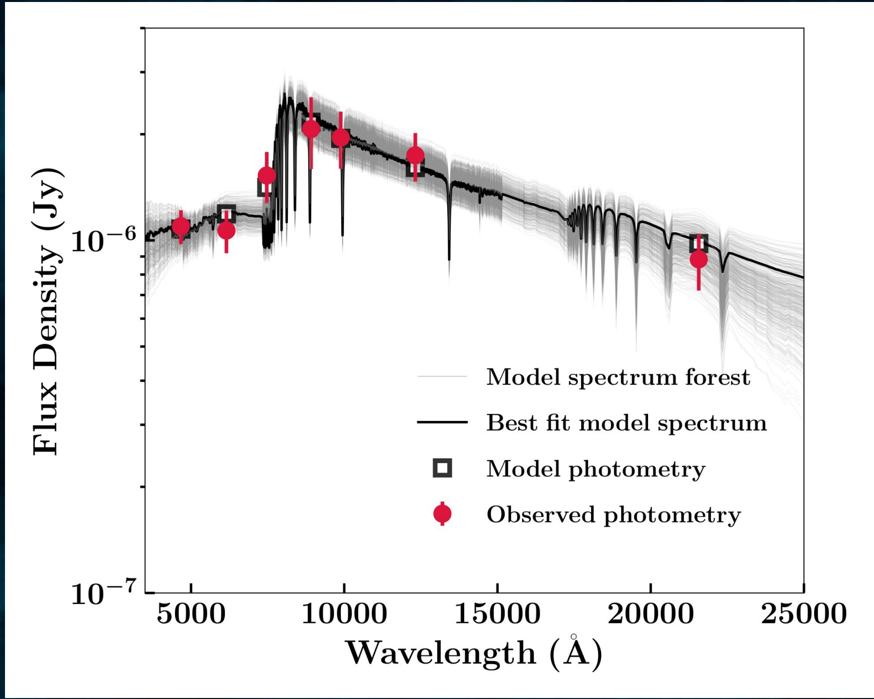
- A short GRB detected by *Swift-* BAT and *Fermi* GBM on 21 December 2020 at 23:06:34 UTC with T_{90} duration of ~0.14 sec.
- At a high redshift (*z = 1.045, de Ugarte Postigo et. al 2020)* w.r.t. Median redshift of short GRBs.



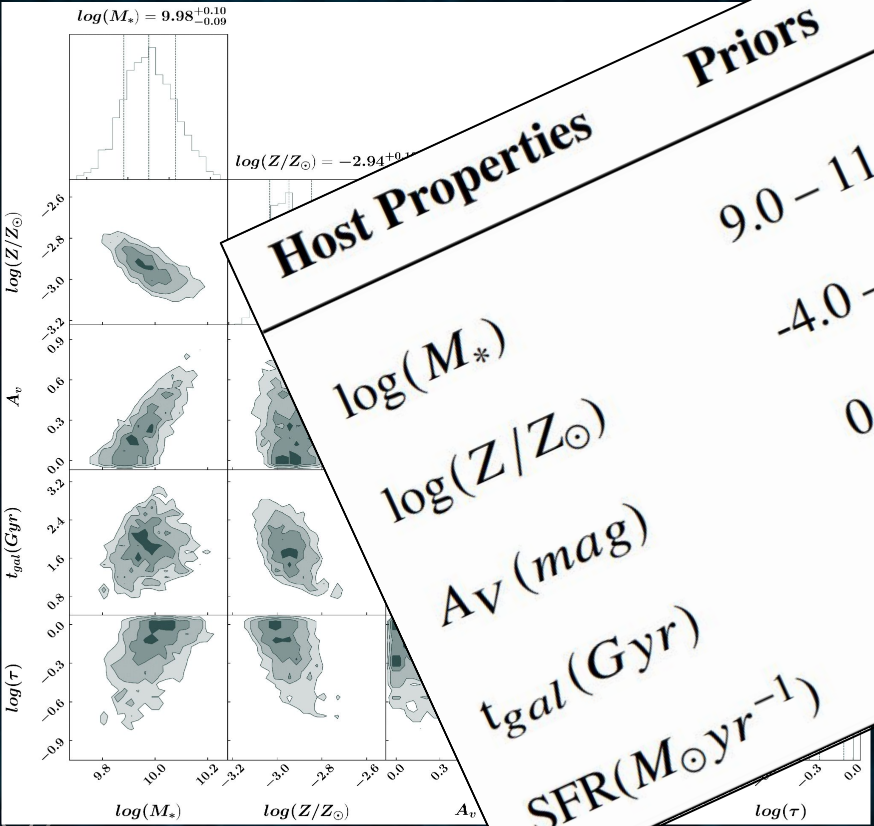

J
r
i
r (uplims)
Flux Density (mJy)
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
Time since GBM trigger (days)

Host properties of GRB 201221D

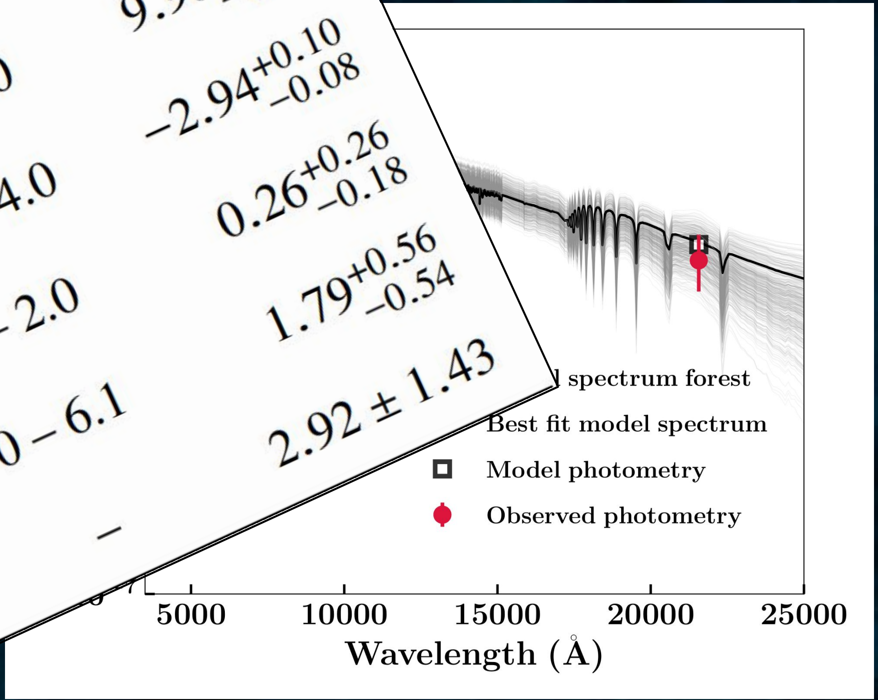


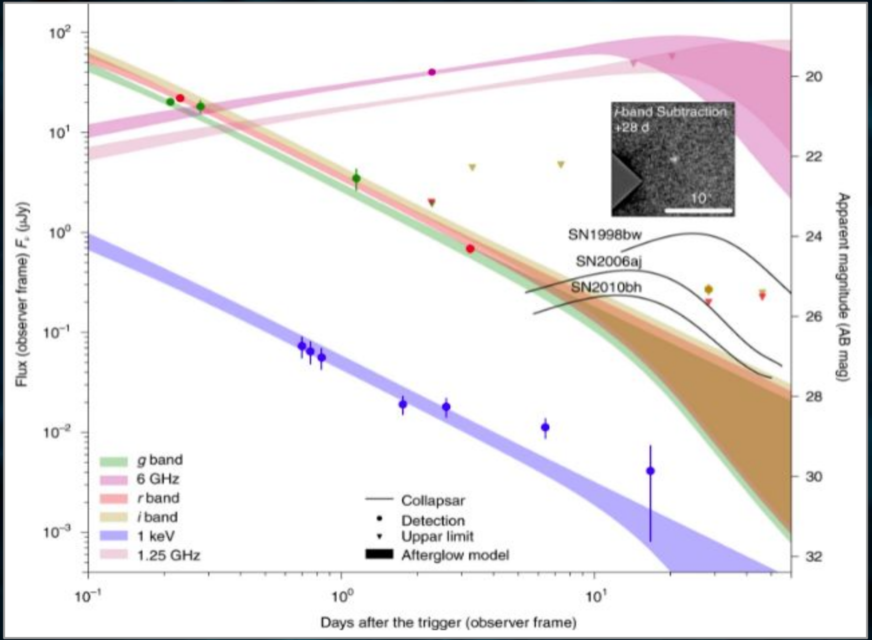


Host properties … RB 201221D



Host Properties	Priors	Values
$\log(M_*)$	9.0 – 11.0	$9.98^{+0.10}_{-0.09}$
$\log(Z/Z_\odot)$	-4.0 – 4.0	$-2.94^{+0.10}_{-0.08}$
$Av\,(mag)$	0 – 2.0	$0.26^{+0.26}_{-0.18}$
$t_{gal}(Gyr)$	0 – 6.1	$1.79^{+0.56}_{-0.54}$
$SFR(M_\odot yr^{-1})$	–	2.92 ± 1.43



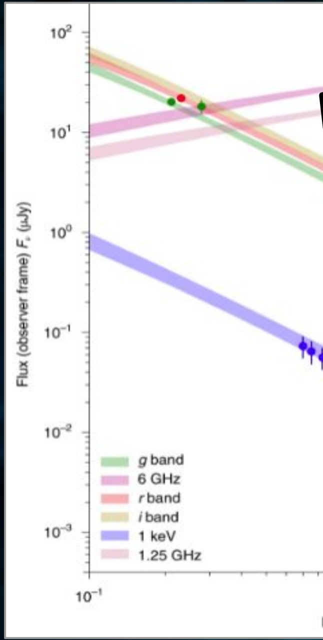


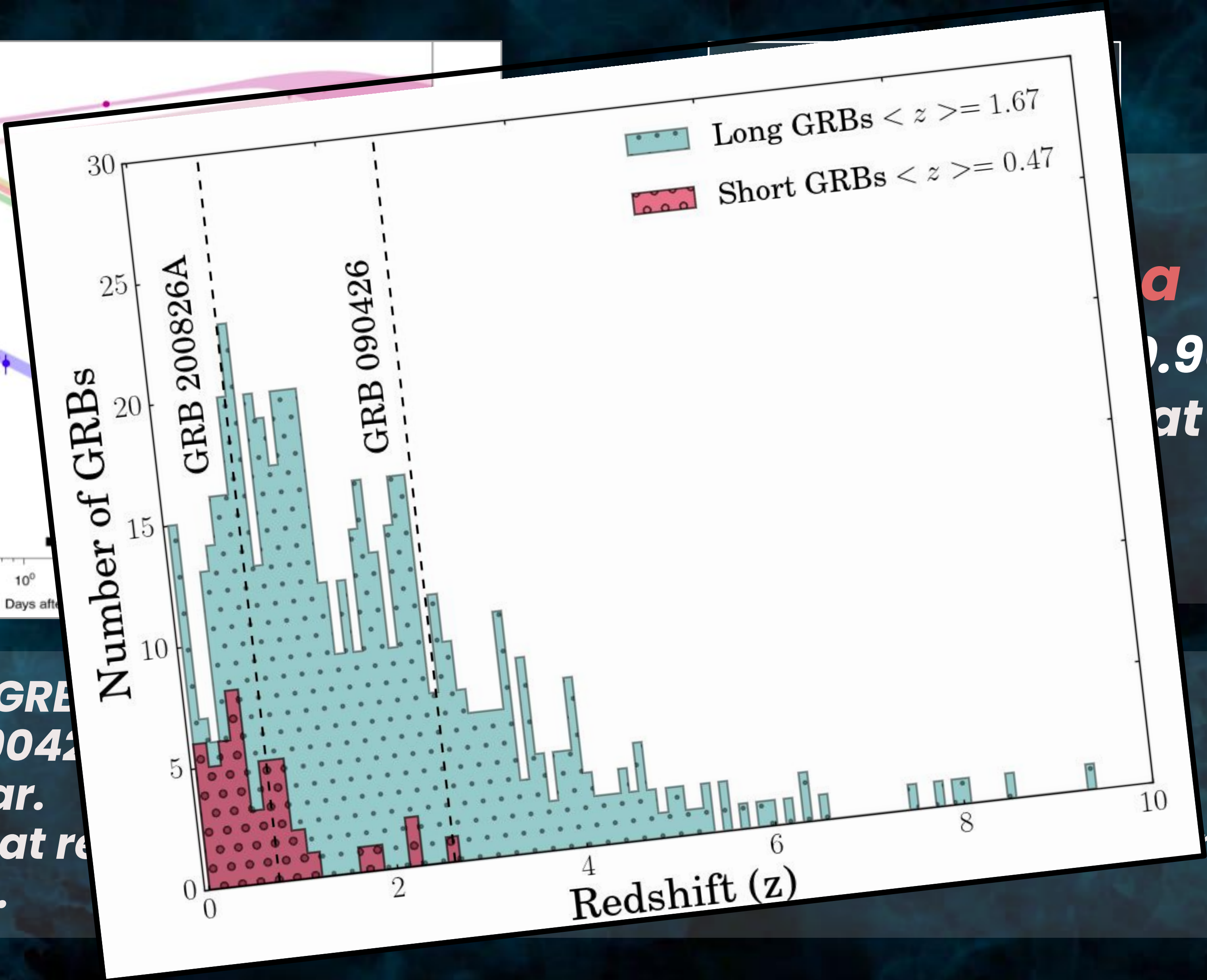
Ahumda et al. 2021

GRB 200826A: the Shortest GRB from a collapsar with T_{90}=0.96 sec (Ahumada et al. 2021) at a redshift of 0.748.

Apart from GRB 200826A,

- ***SGRB 090426 with T_{90} = 1.25 s and z=2.609, had signatures of collapsar.***
- ***Both lie at relatively high redshifts as compared to the median SGRB redshift.***





a

.96 sec

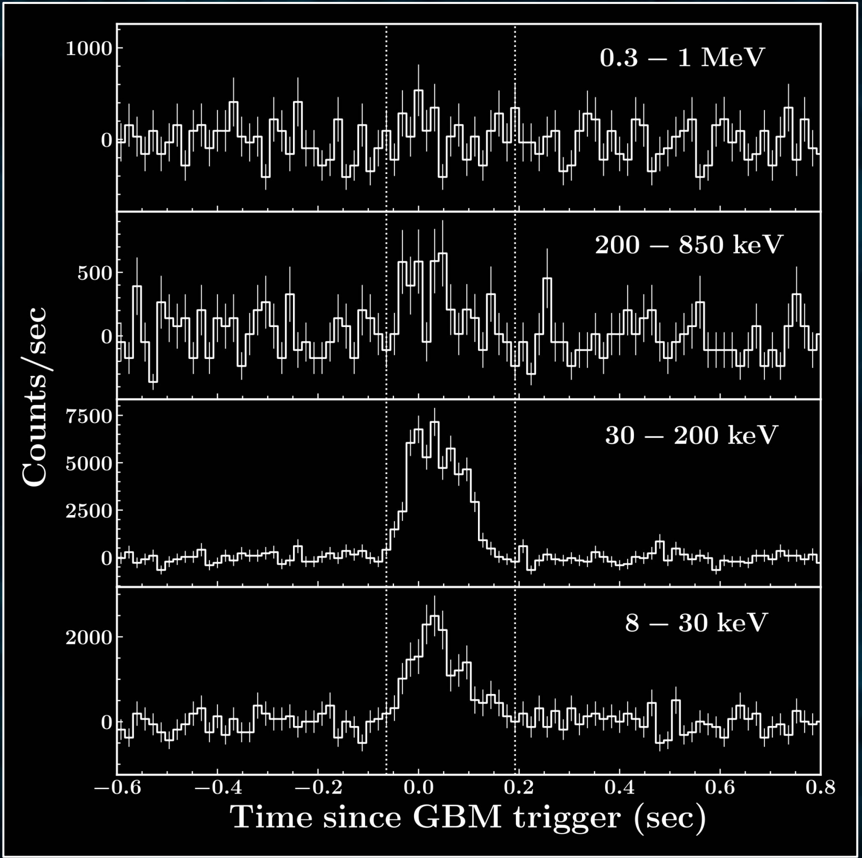
at a

Apart from GRB

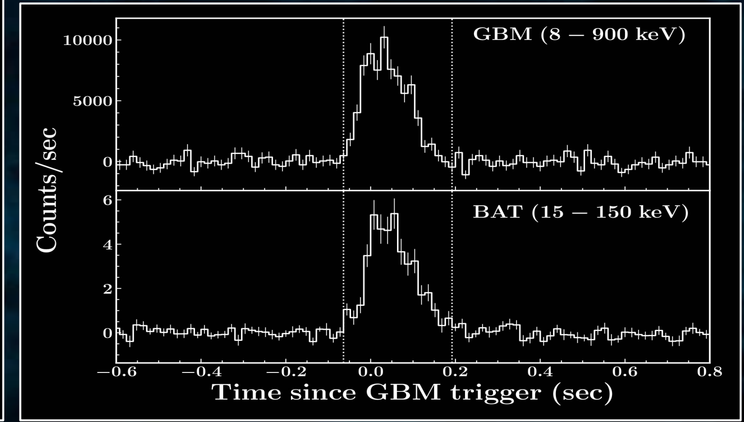
- *SGRB 09042*
  collapsar.
- *Both lie at re*
  redshift.

n SGRB

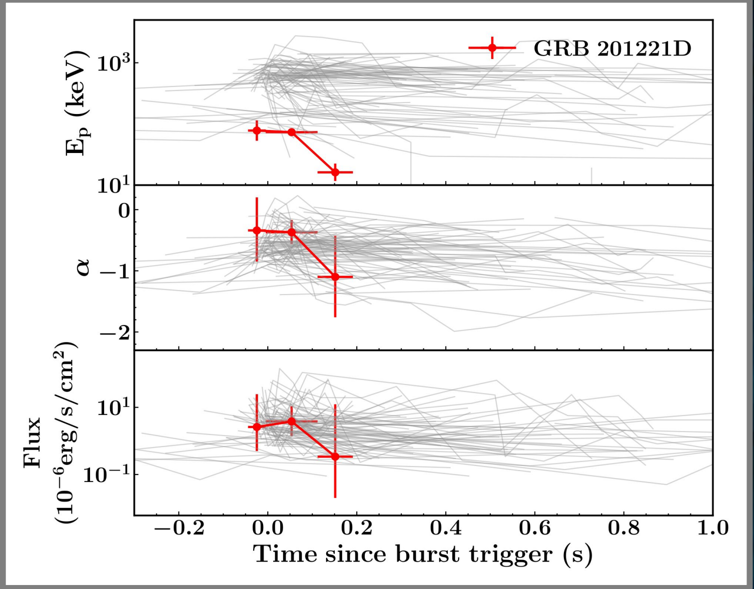
Prompt Emission Properties



$T_{90,i}$(s)	0.06+-0.02
$E_{\gamma,iso}$ (10^{51} erg)	2.76+-0.21
$E_{p,i}$ (keV)	226+-31.8
Spectral lag (s)	0.07+-0.05
F_{nc}	0.95+-0.09

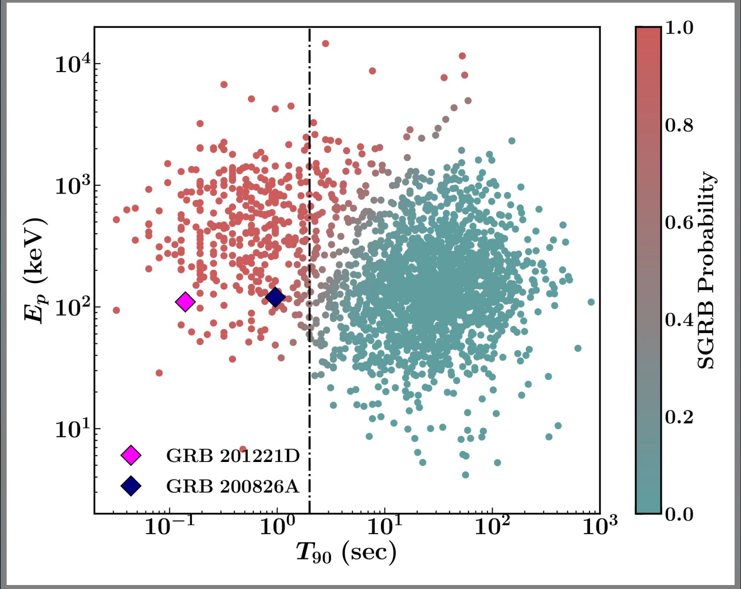


Prompt Emission Properties



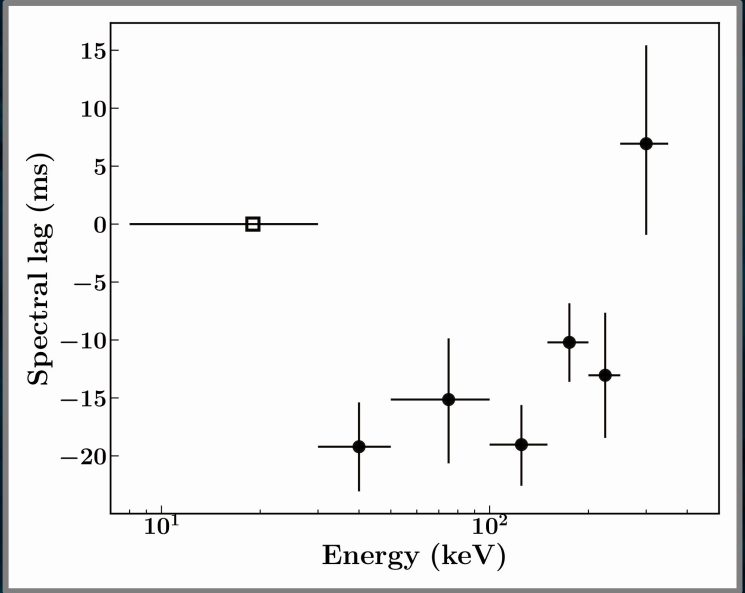
Evolution of spectral parameters for GRB 201221D and its comparison with the sample of SGRBs.

The photon index and flux values are typically comparable to the SGRB sample. However, the peak energy value of the burst is quite low in the last bin compared to the sample of SGRBs.

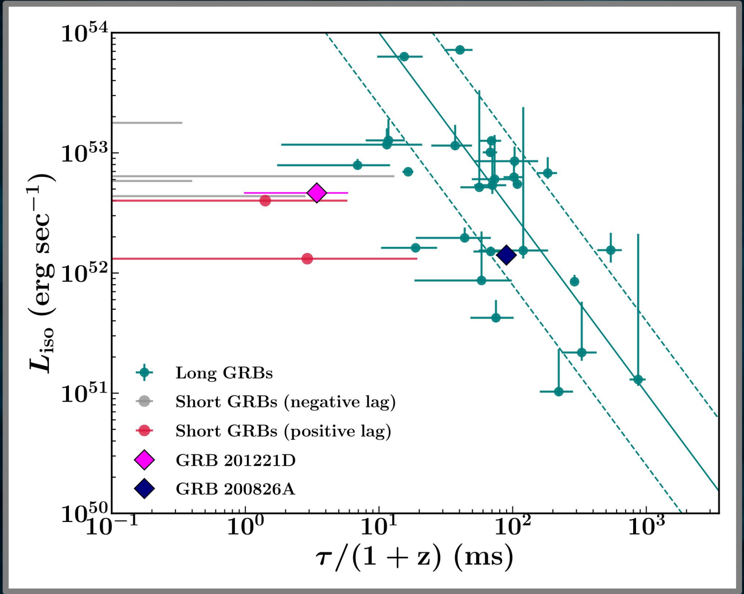


The E_p -T_{90} distribution for GRBs taken from the Fermi/GBM catalogue. The probability of GRB 201221D to be a short burst (estimated using BGMM) is 98 %.

Prompt Emission Properties



The evolution of spectral lag for GRB 201221D in different energy channels using the Fermi data. The value of lag is close to zero, as expected in the case of SGRBs.



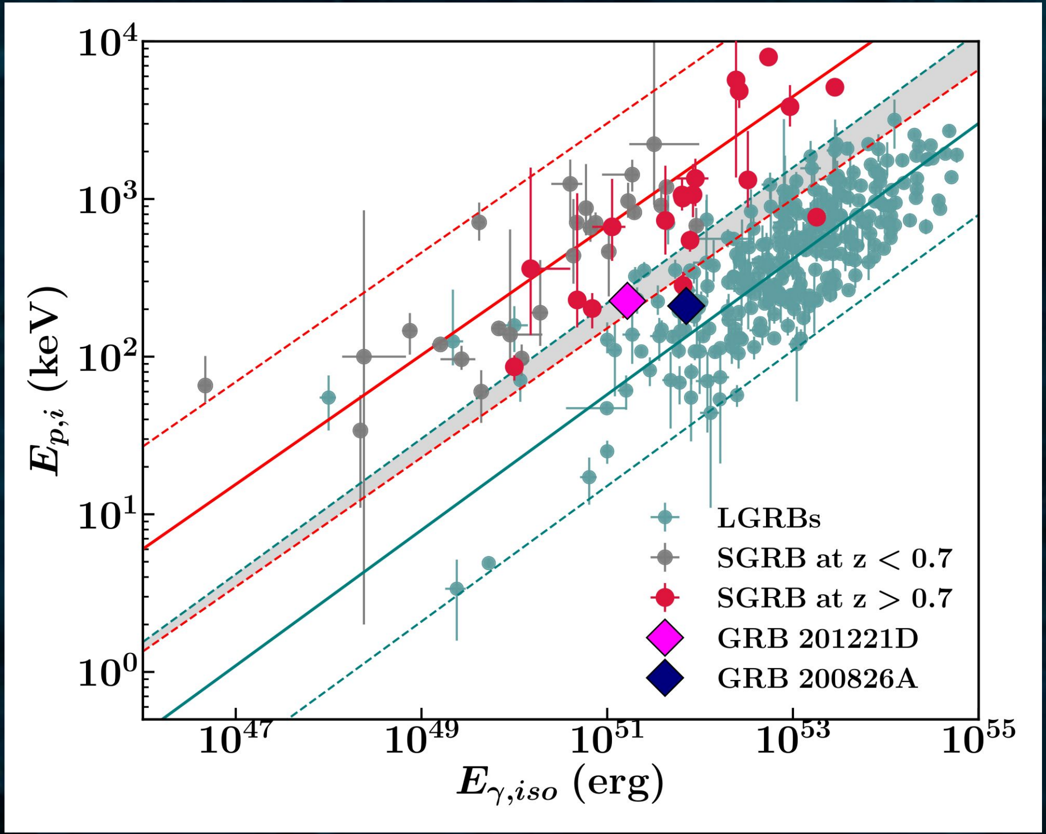
GRB 201221D and GRB 200826A in the lag-luminosity plane. GRB 201221D does not lie within the 2σ region of the lag-luminosity correlation. However, GRB 200826A follows this correlation, which is generally true for long GRBs.

Are High-z SGRBs similar to Low-z SGRBs?

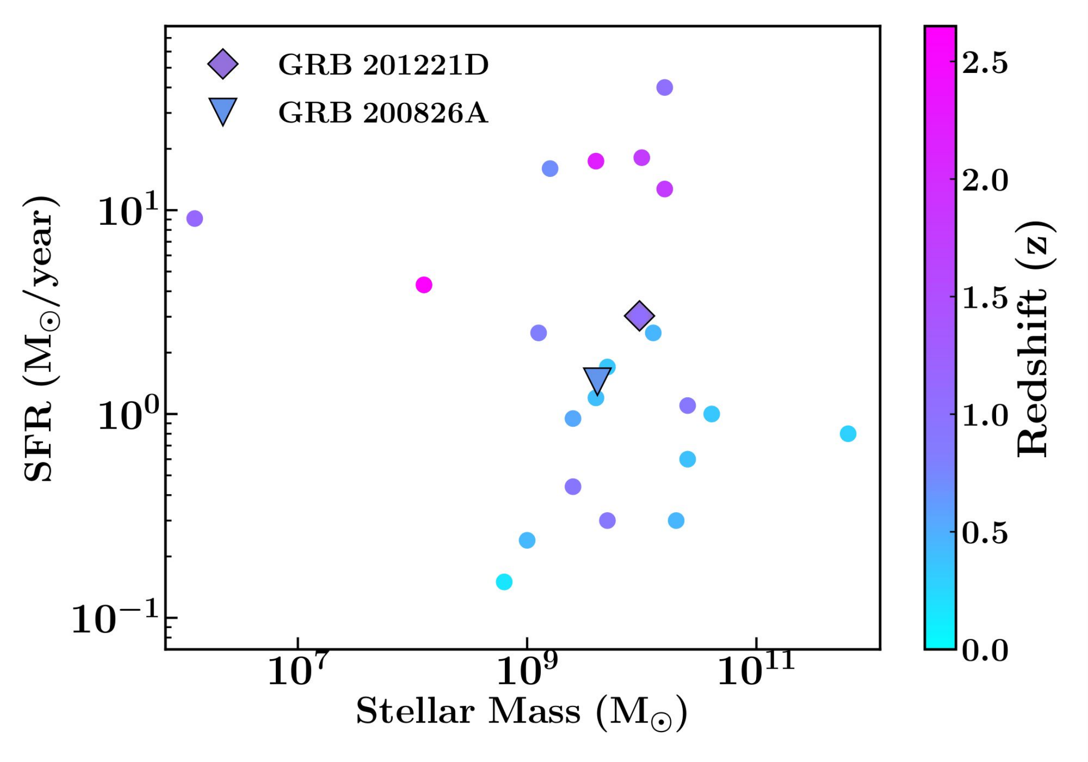
- Motivated by the fact that some of the SGRBs lying at a high redshift have signatures of collapsars,
  And,
- Earlier prediction by Berger et al. (2007) that there can be a new population of SGRBs at higher redshifts, we examine the similarity and differences between SGRBs at low and high redshifts.

- Considering the median redshift of SGRBs, we divide the sample of SGRBs into two groups; Group 1-low redshift SGRBs with $z < 0.7$, and Group 2-high redshift SGRBs with $z \geq 0.7$.

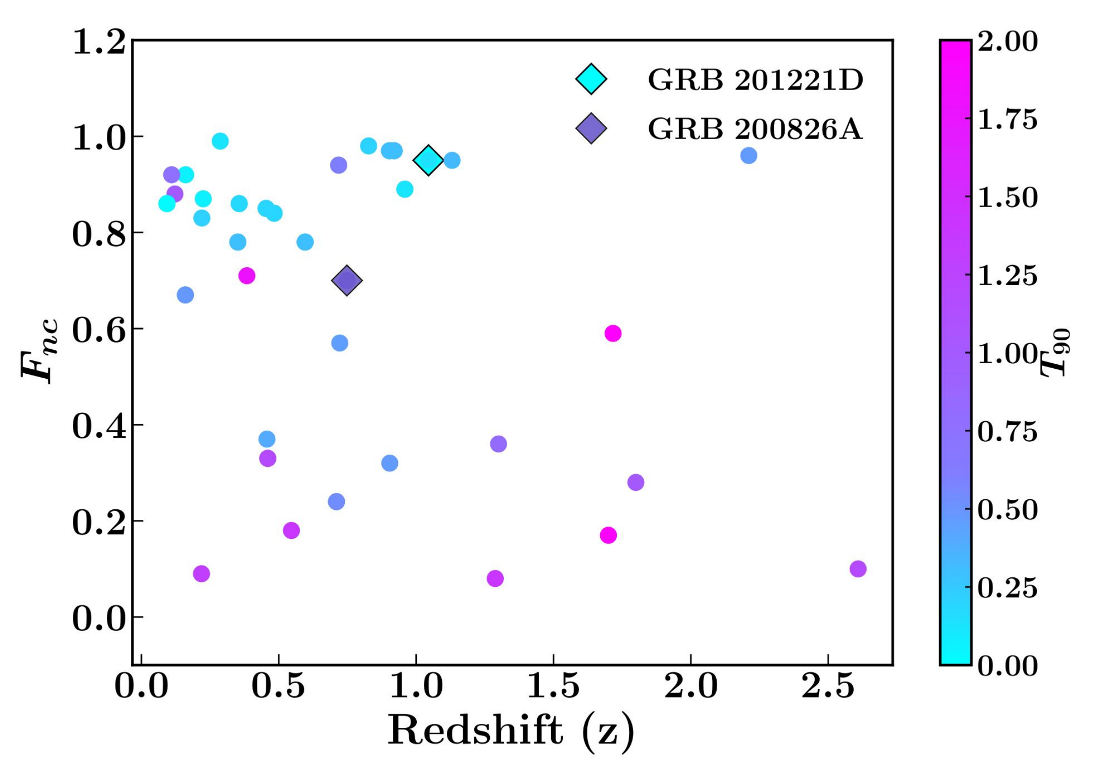
Locations in Amati plane



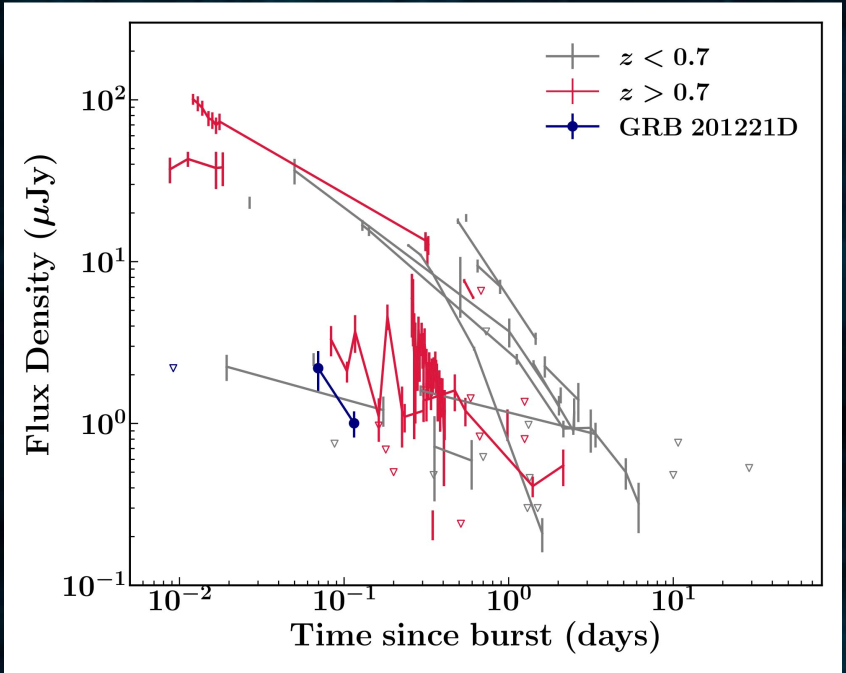
Host properties

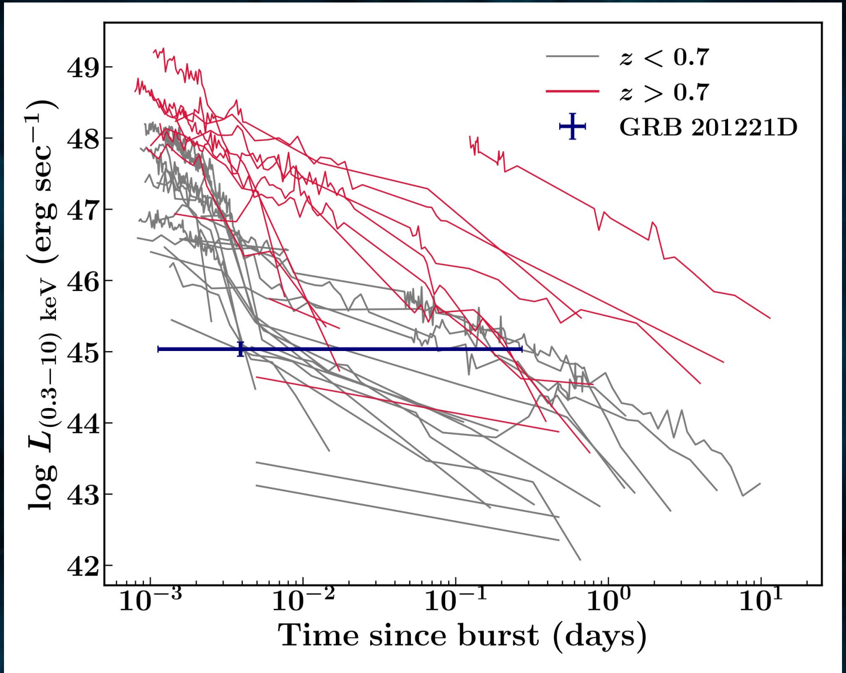


Non-collapsar probabilities



X-ray and optical afterglows





X-ray

Optical

Take home message

- ***We carried the observation of SGRB 201221D using 3.6m DOT.***
- ***SGRBs with $z > 0.7$ are located close to the long GRB track in the Amati plane. Three SGRBs (including GRB 200826A) lie on the long GRB track. Some of these SGRBs, including GRB 201221D lie in the overlapping region of 2σ regions of long and SGRBs.***
- ***The non-collapsar probabilities for some high redshift SGRBs have values <0.5, indicating these SGRBs might result from collapsars.***
- ***SGRBs lying at high redshifts have similarities to long GRBs, indicating they might have progenitor systems other than compact object mergers***
  or ……
- ***There might exist subgroups within the SGRBs originating through different channels***
- ***Machine learning algorithms can play a crucial role to solve the classification conundrum.***

Thank you

For more details, please go through our recent publication:

Dimple et al. 2022, MNRAS, 516, 1, 1.

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Questions ???