INTRO

Universality of Peaking Time of Supernovae Associated with Gamma-Ray Bursts

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for
ICRANet-ISFAHAN Astronomy Meeting
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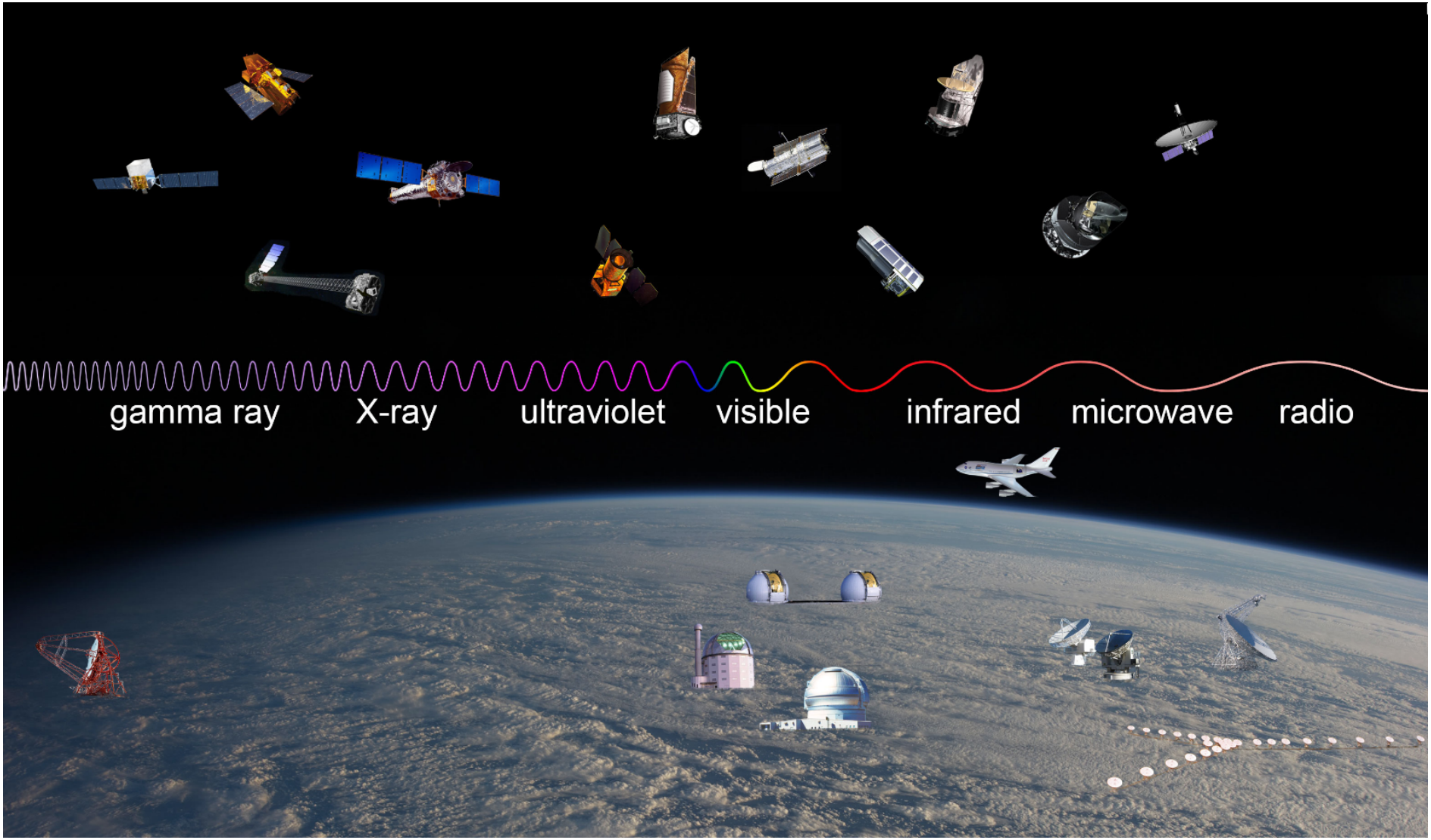


Credit: Observatory images from NASA, ESA (Herschel and Planck), Lavochkin Association (Specktr-R), HESS Collaboration (HESS), Salt Foundation (SALT), Rick Peterson/WMKO (Keck), Germini Observatory/AURA (Gemini), CARMA team (CARMA), and NRAO/AUI (Greenbank and VLA); background image from NASA

- observational range

1. GRB background
2. Methods
3. Results & Discussion

Observational fact 1:

Isotropic distribution on the sky $\rightarrow$ Extragalactic origin $\rightarrow$ High z

The Astrophysical Journal, 893:46 (14pp), 2020 April 10

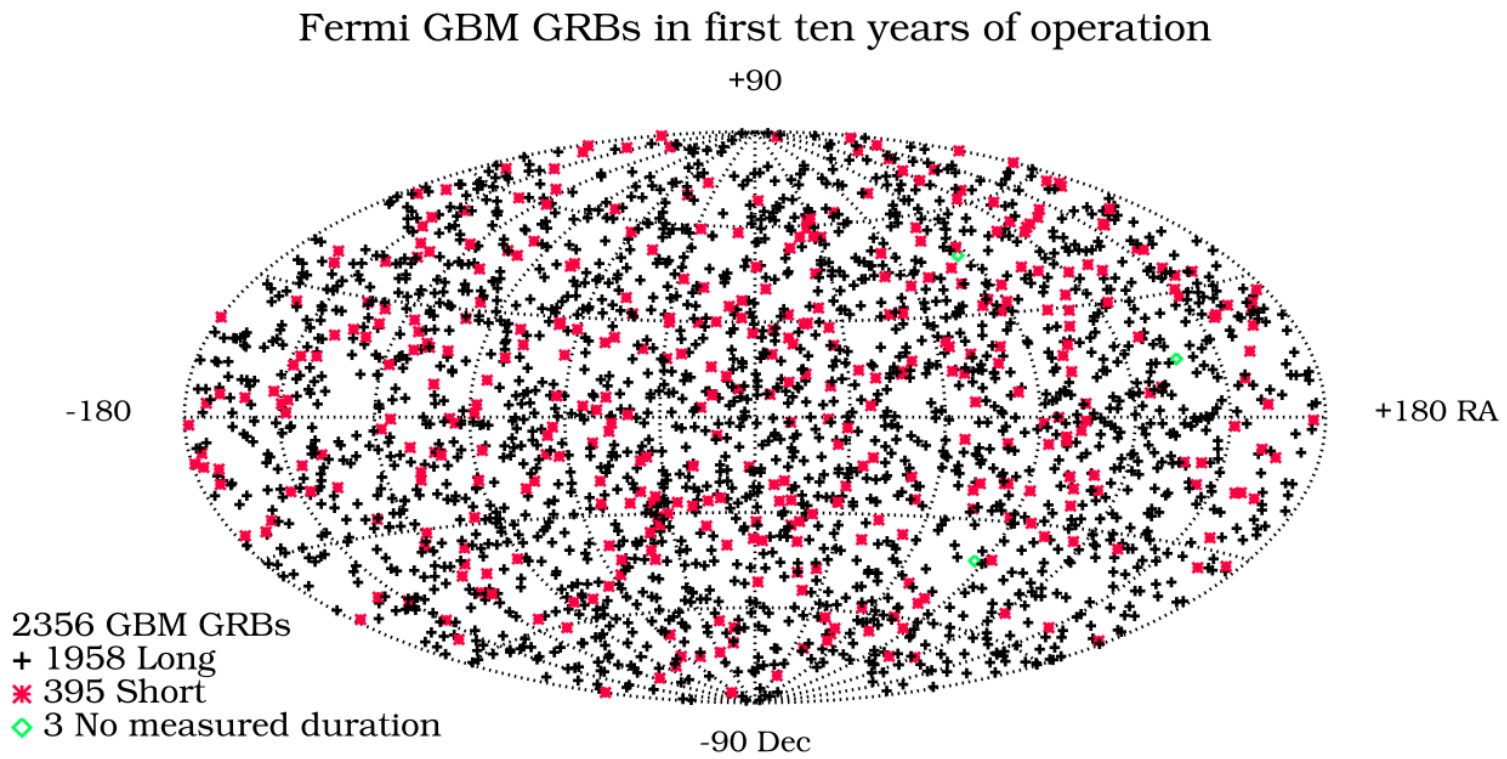
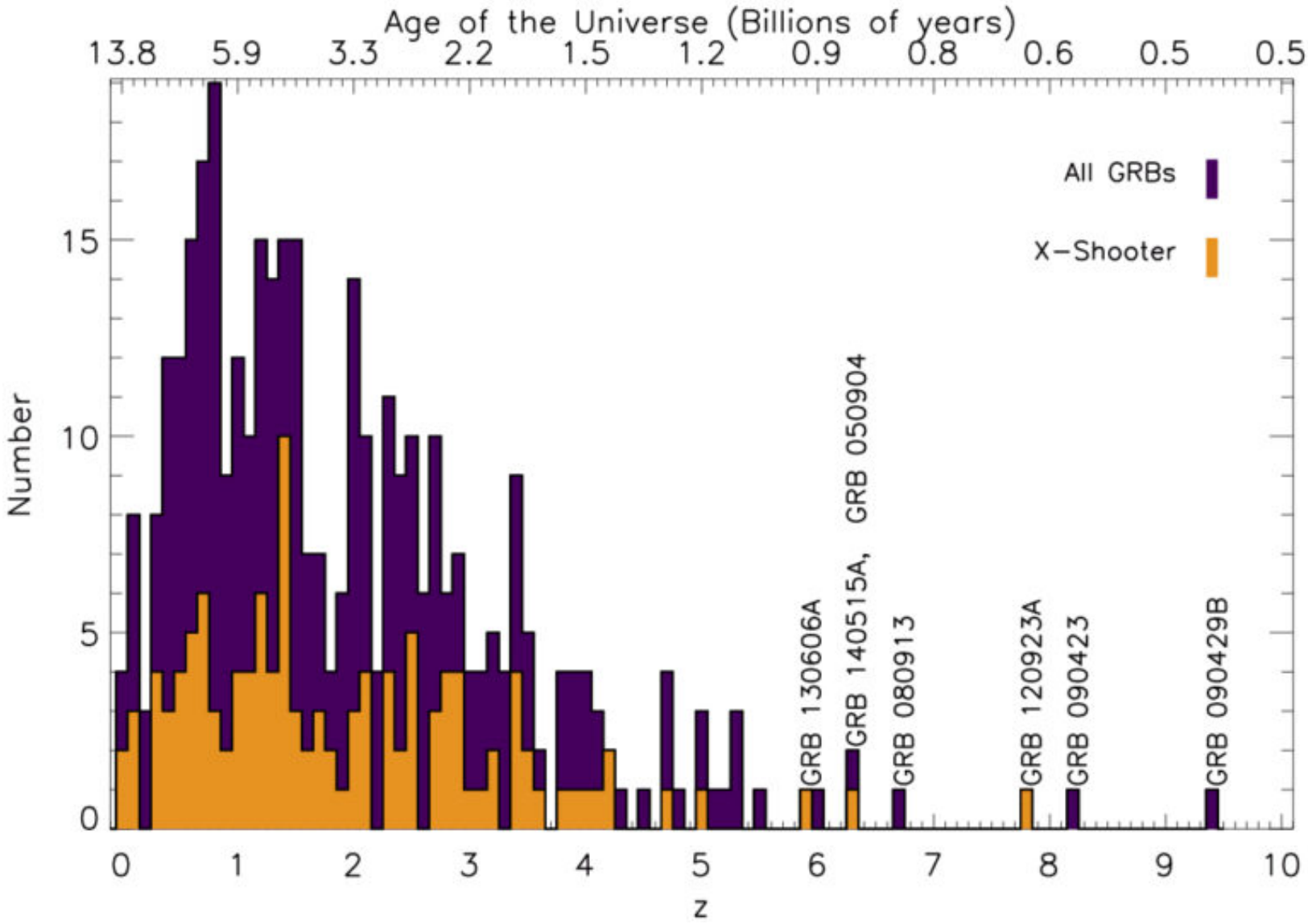


Figure 3. Sky distribution of GBM-triggered GRBs in celestial coordinates. Crosses indicate long GRBs ($T_{90} > 2$ s); asterisks indicate short GRBs.

von Kielnin et al. (2020) ApJ 893, 46



Annalisa De Cia (2011) PhD Thesis

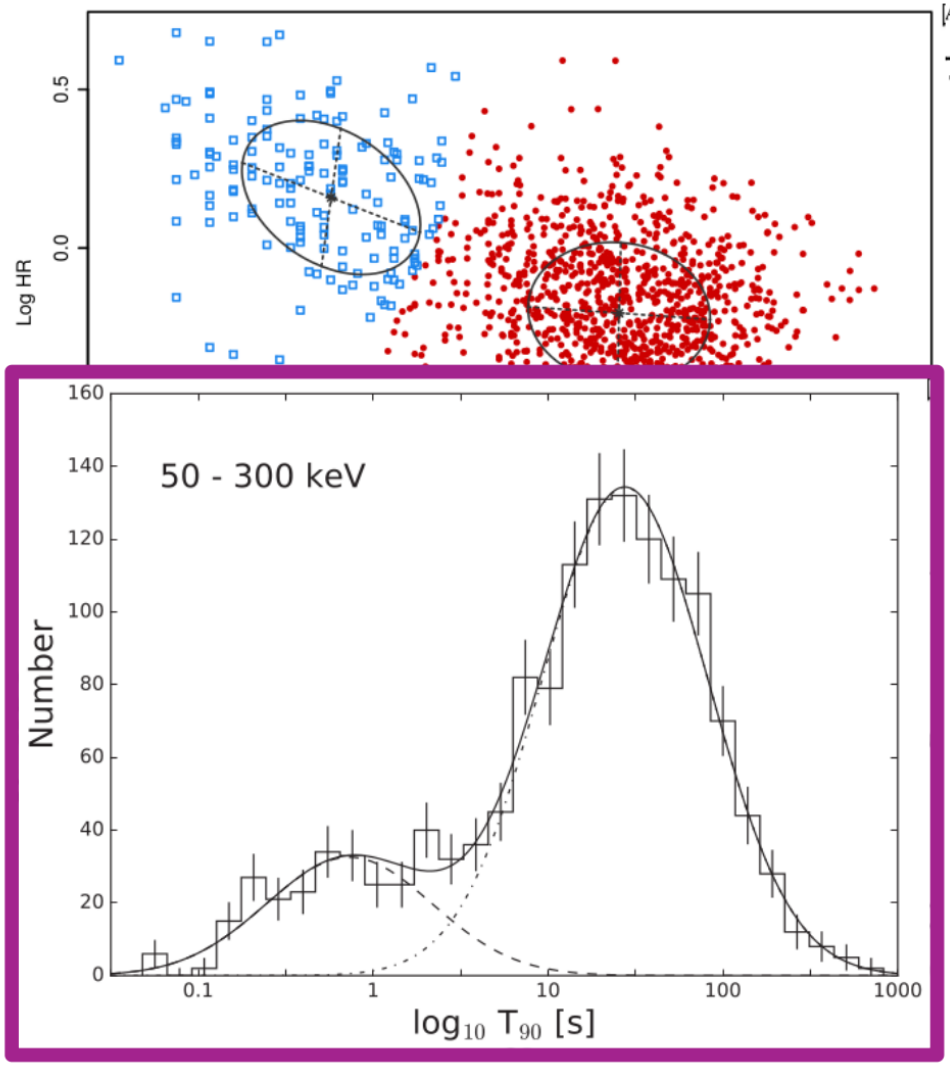
Observational fact 2:

Temporal bimodality (long/short duration GRBs)

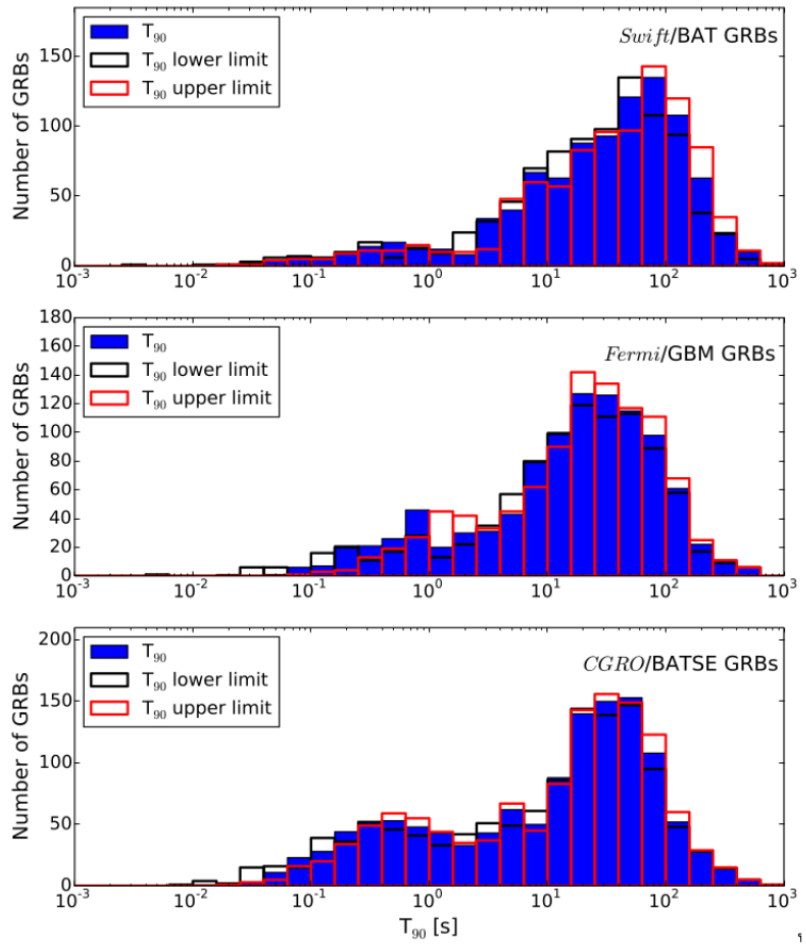
↓

Hints on the progenitors

*not anymore, because duration hints on the progenitors



AMMA-RAY BURSTS: I AND II
THE ASTROPHYSICAL JOURNAL, 829:7 (47pp), 2016 September 20

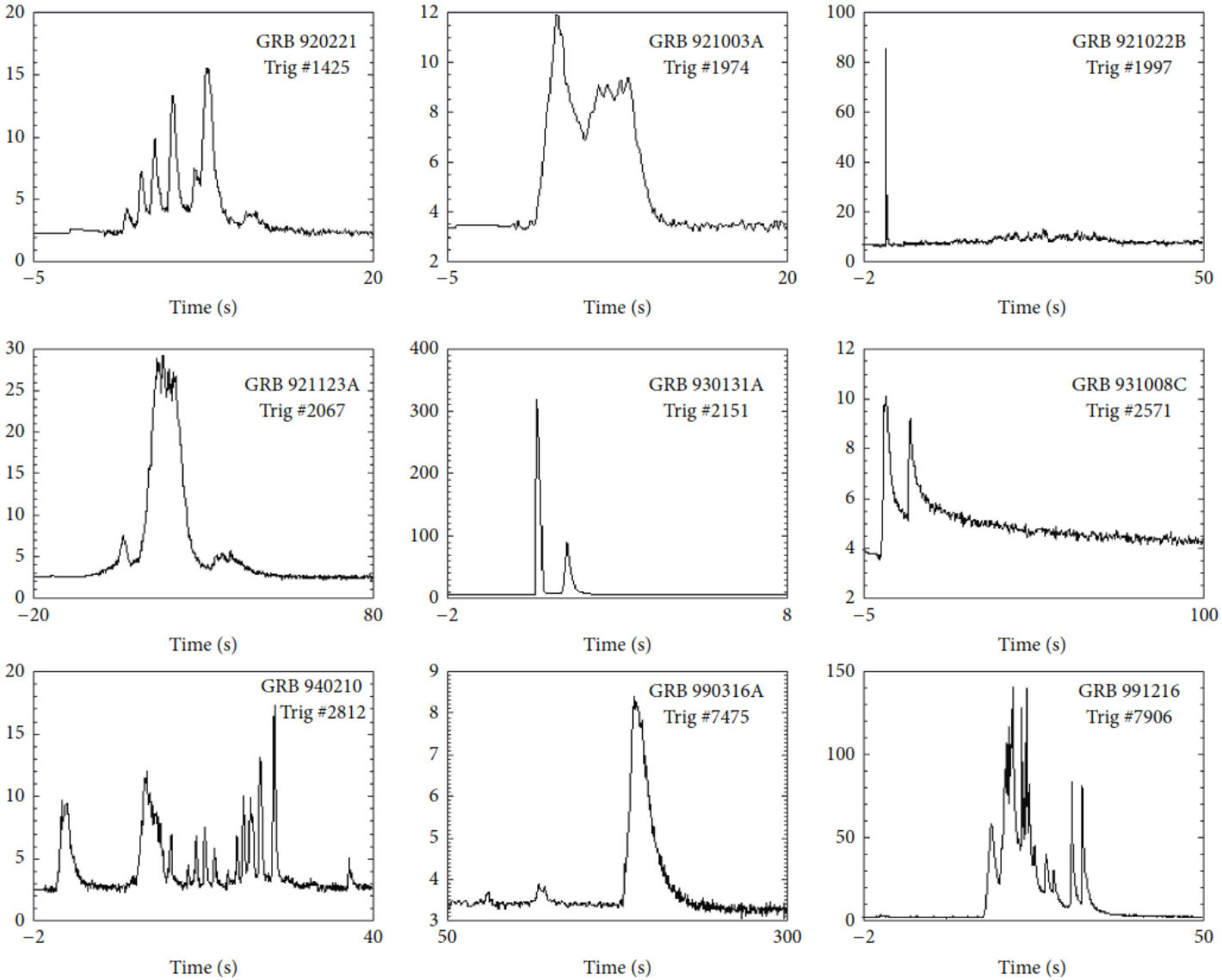


Bhat et al. (2016) ApJS 223, 28

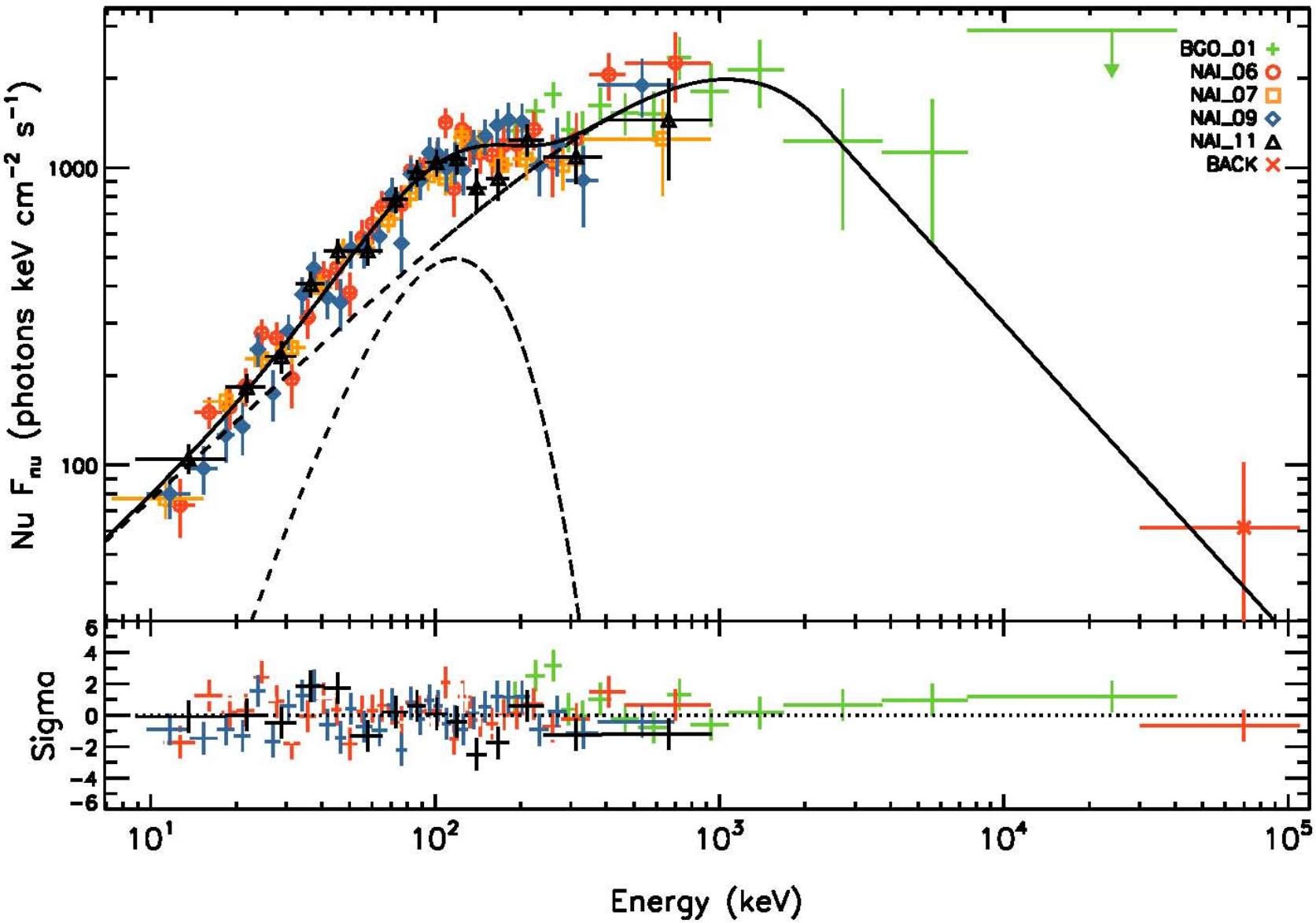
Lien et al. (2016) ApJ 829, 7

Observational fact 3:

Uniqueness of light curves
but
Commonness of spectra



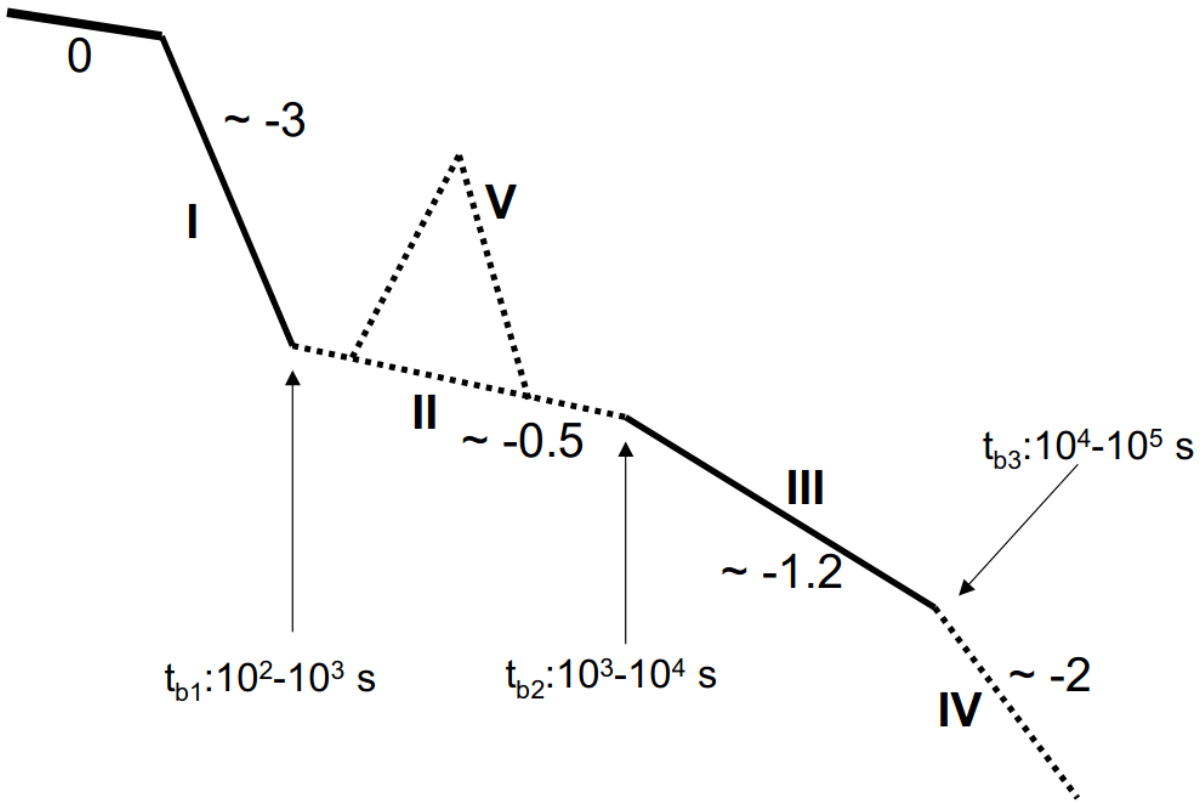
Daniel Perley from BATSE archive (http://gammaray.msfc.nasa.gov/batse/grb/catalog/)



Axelsson (2013) EAS Publications Series 61, 53 (object: GRB 110721A)

Searches for similarity:

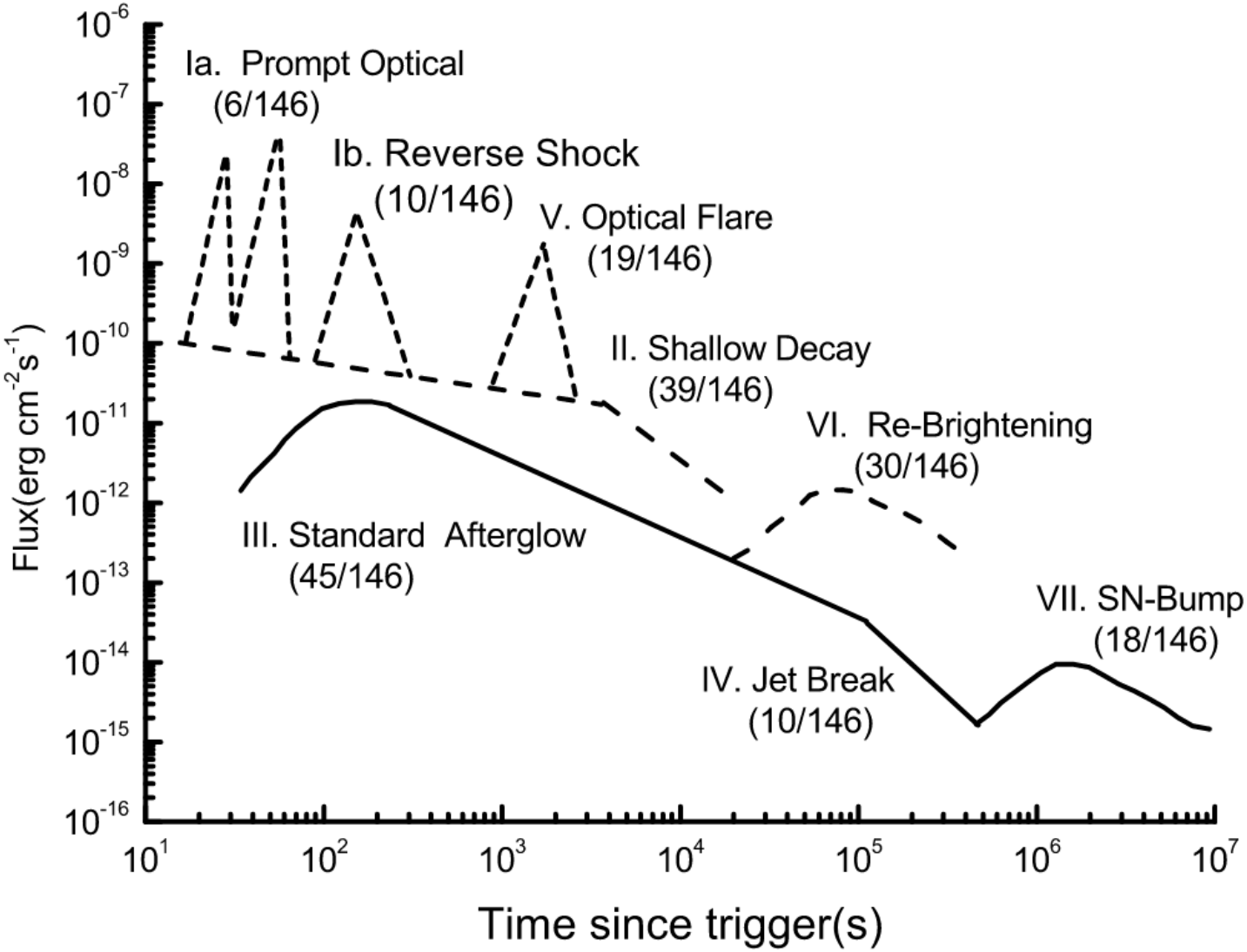
X-ray afterglow



Zhang et al. (2006) ApJ 642, 354 Nousek et al. (2006) ApJ 642, 389

Searches for similarity:

Optical afterglow

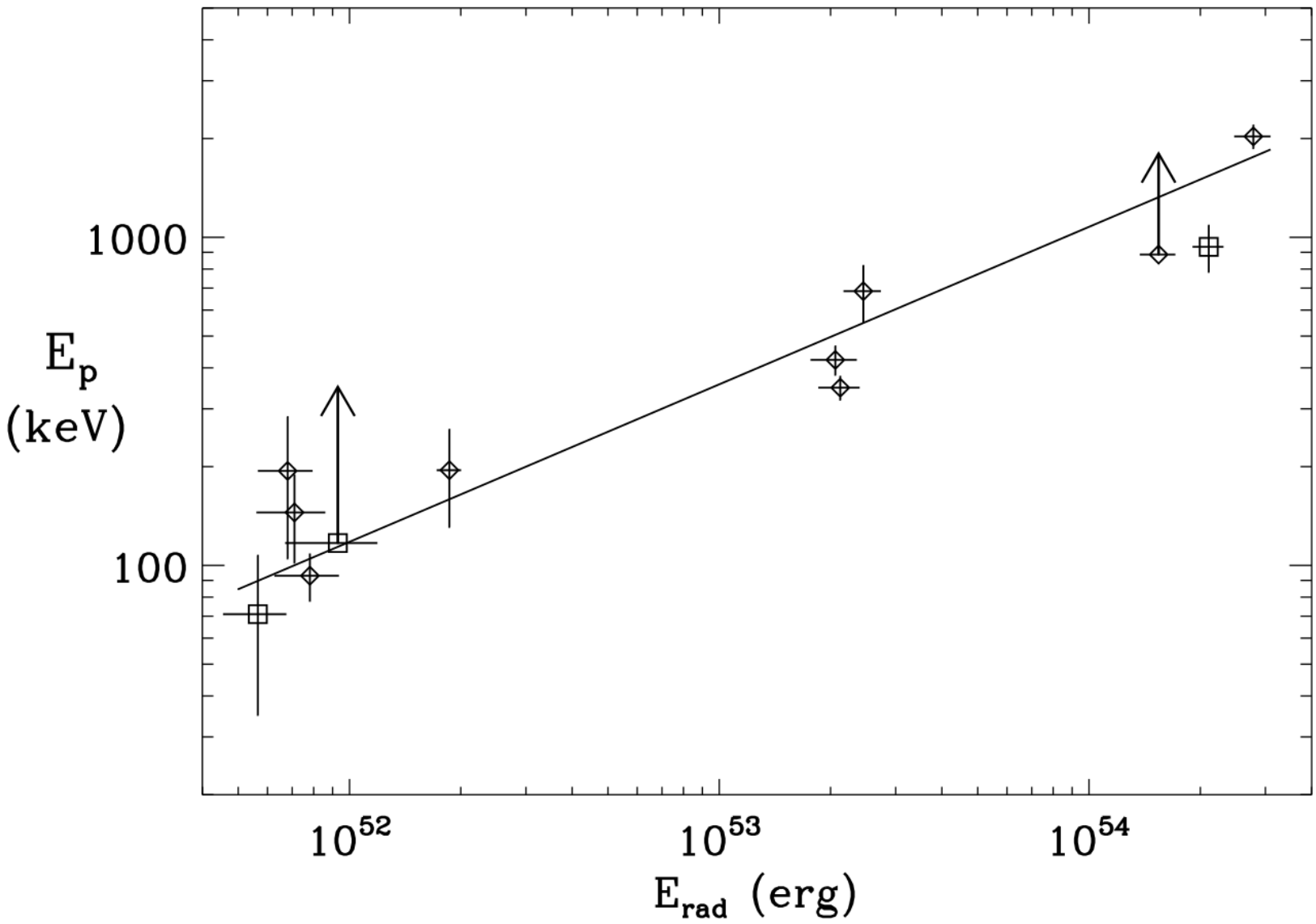


Li et al. (2012) ApJ 758, 27

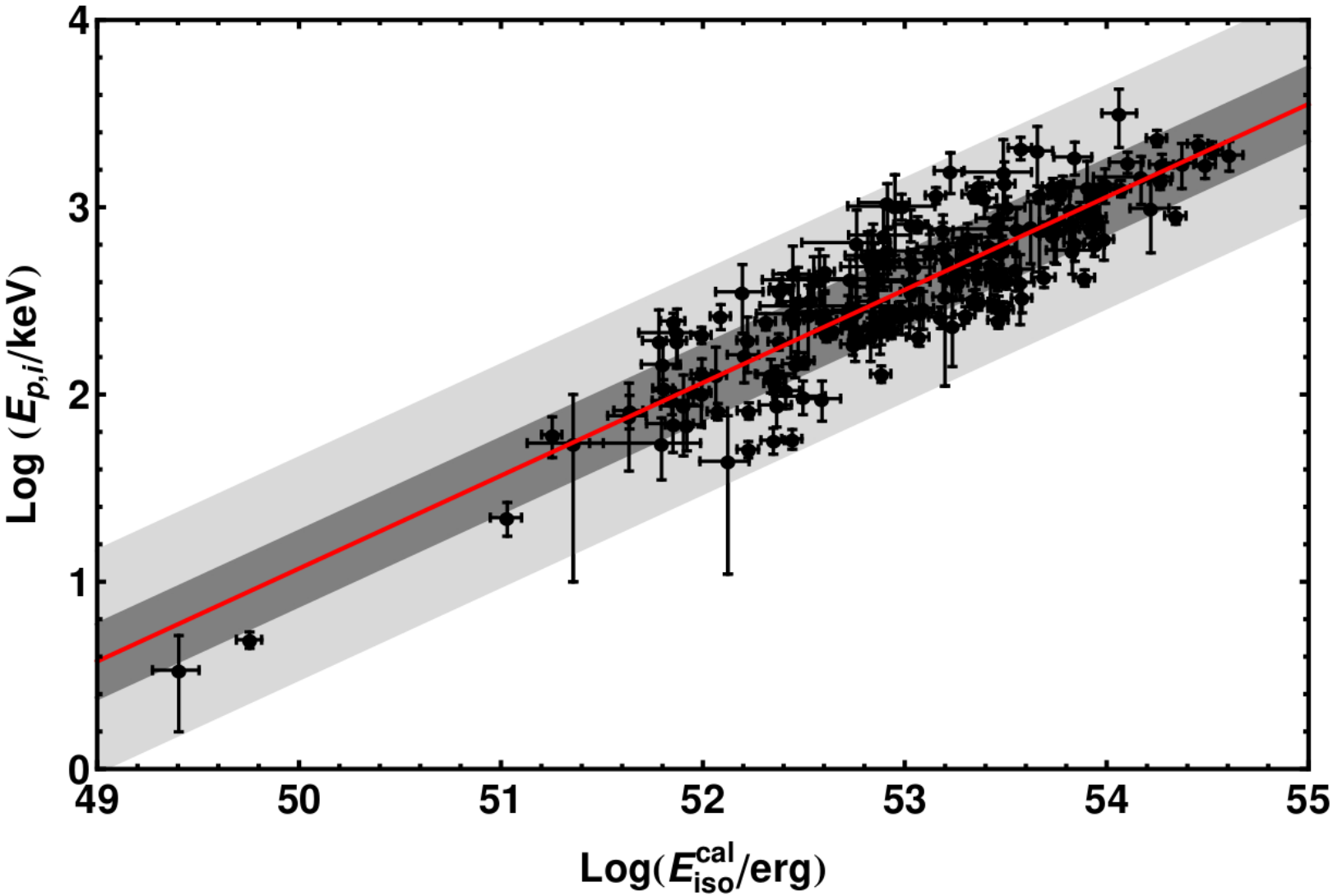
Known phenomenological correlations:

$$E_{\rm peak,intrinsic}\text{-}E_{\rm isotropic}$$

(aka Amati relation for Long GRBs)



Amati et al. (2002) A&A, 390, 81

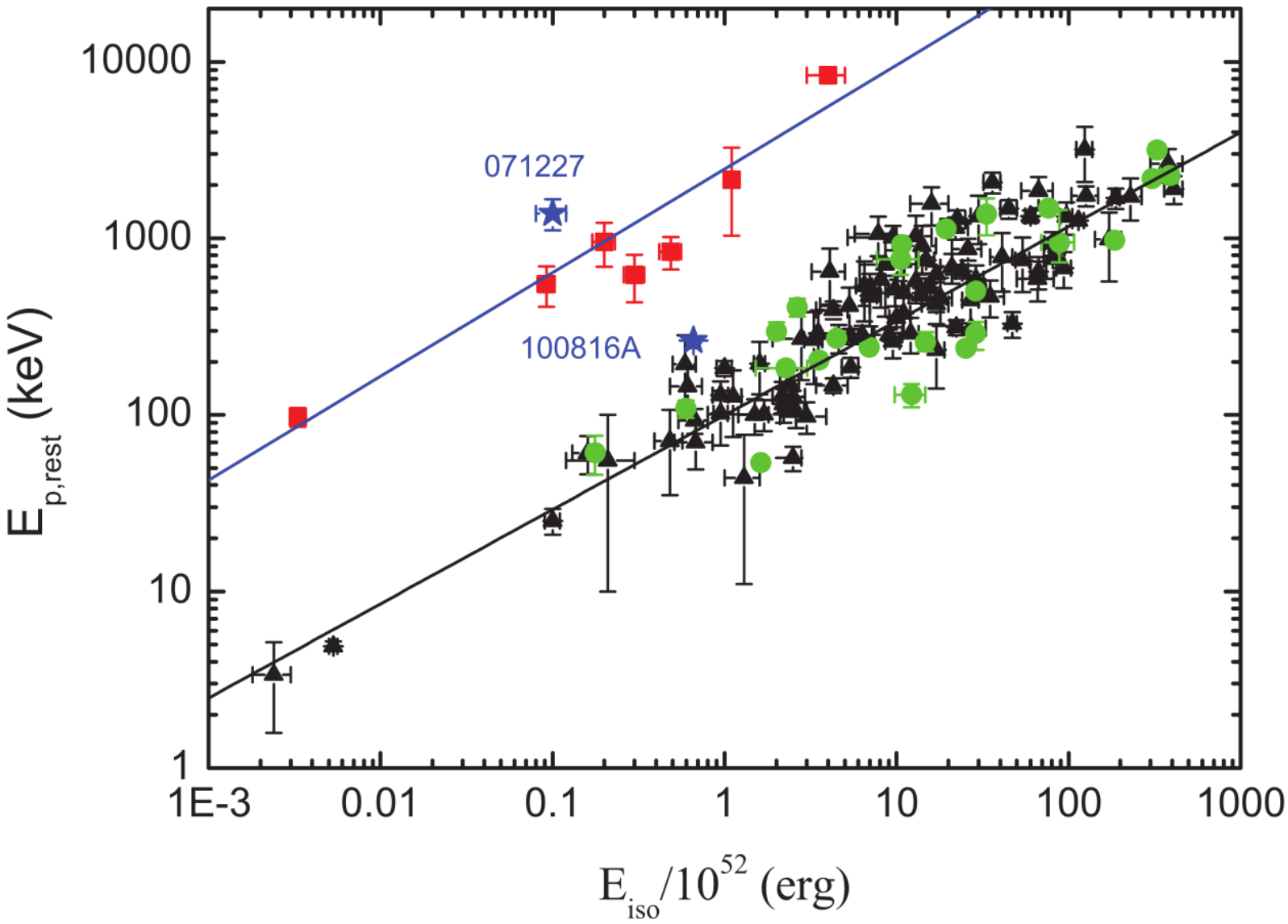


Amati et al. (2019) MNRAS, 486, L46

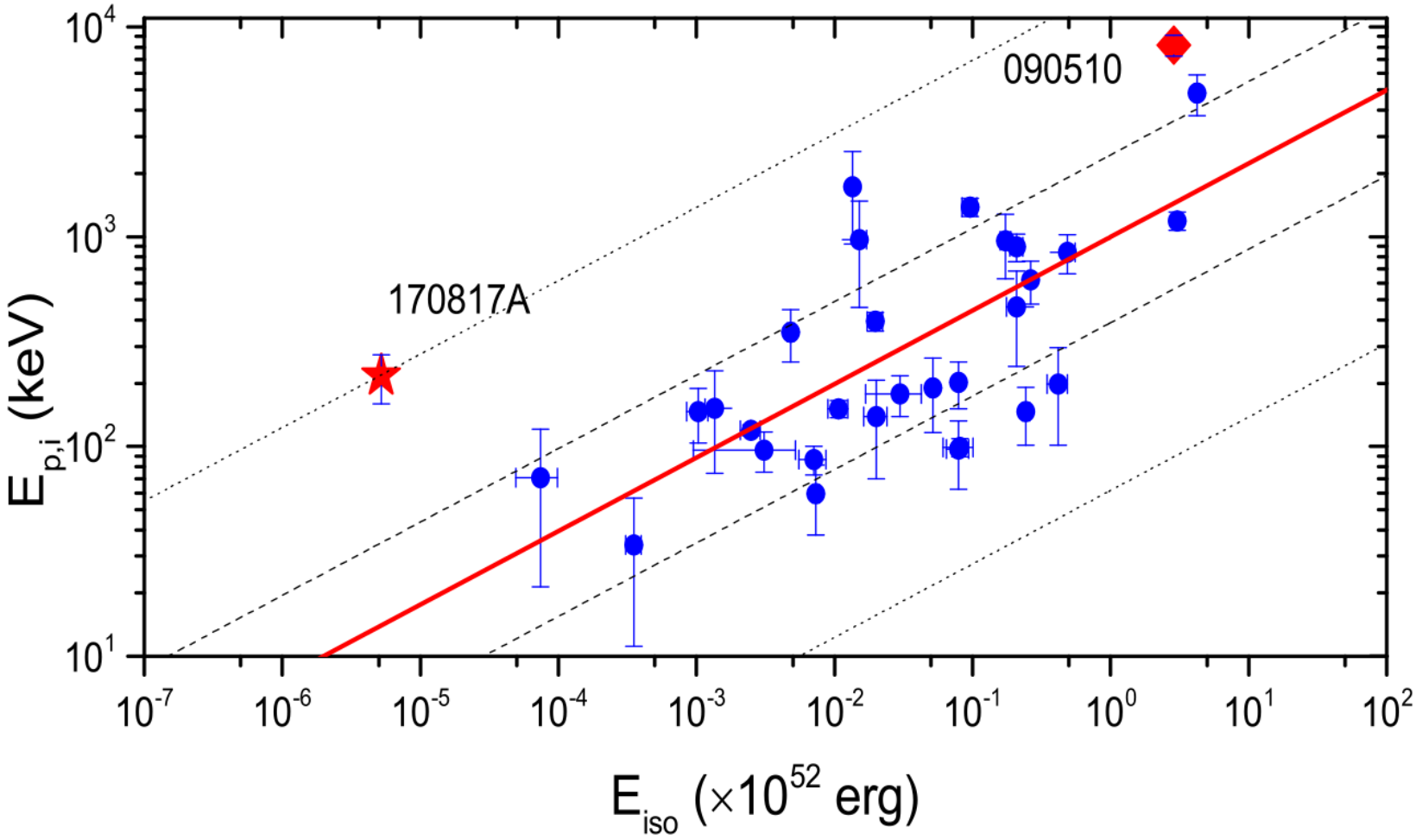
Short GRBs needed longer time to collect the statistics,
but same correlation exists as well

$$E_{\rm peak,intrinsic}\text{-}E_{\rm isotropic}$$

(aka Zhang relation)



Zhang et al. (2012) ApJ, 750, 88



Zhang et al. (2018) PASP, 130, 054202

phenomenology of SN association

Two methods exist to detect a SN in association with a GRB

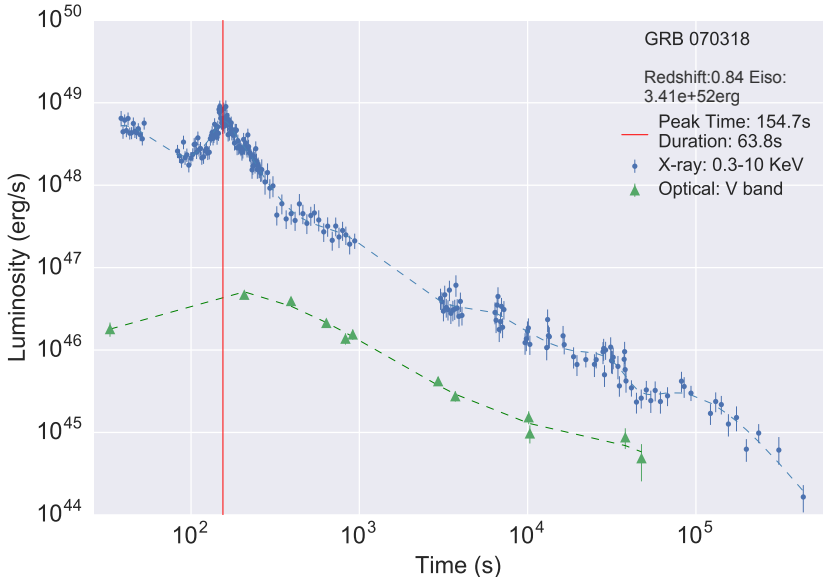
1) photometric identification

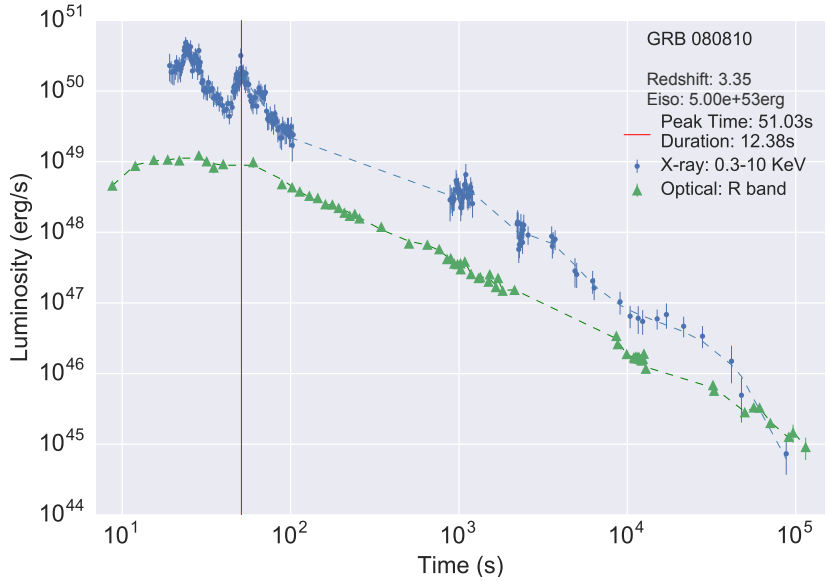
↓

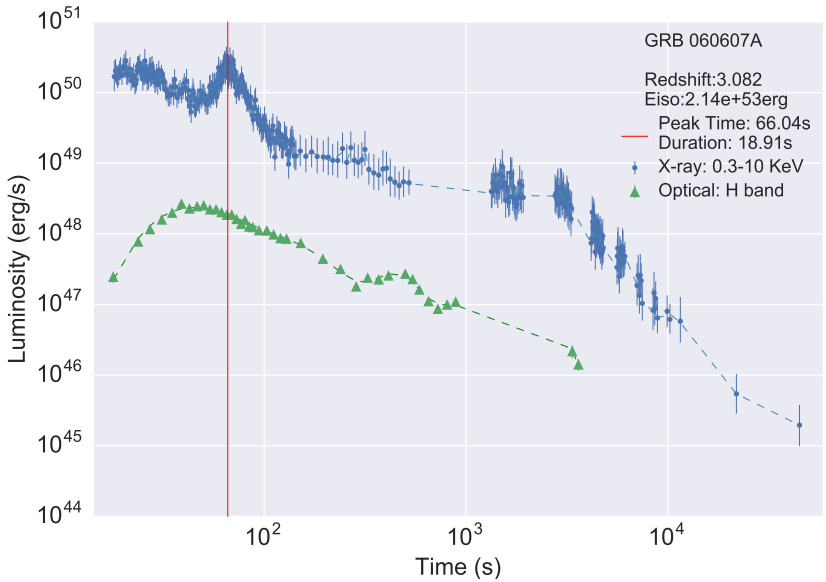
optical light curve behavior

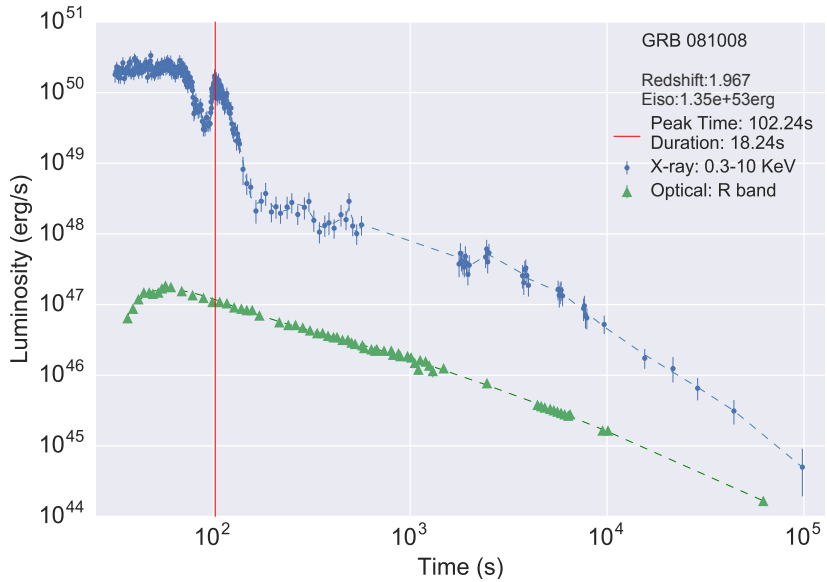
↓

easier to obtain but usually (and unfortunately) the only to obtain



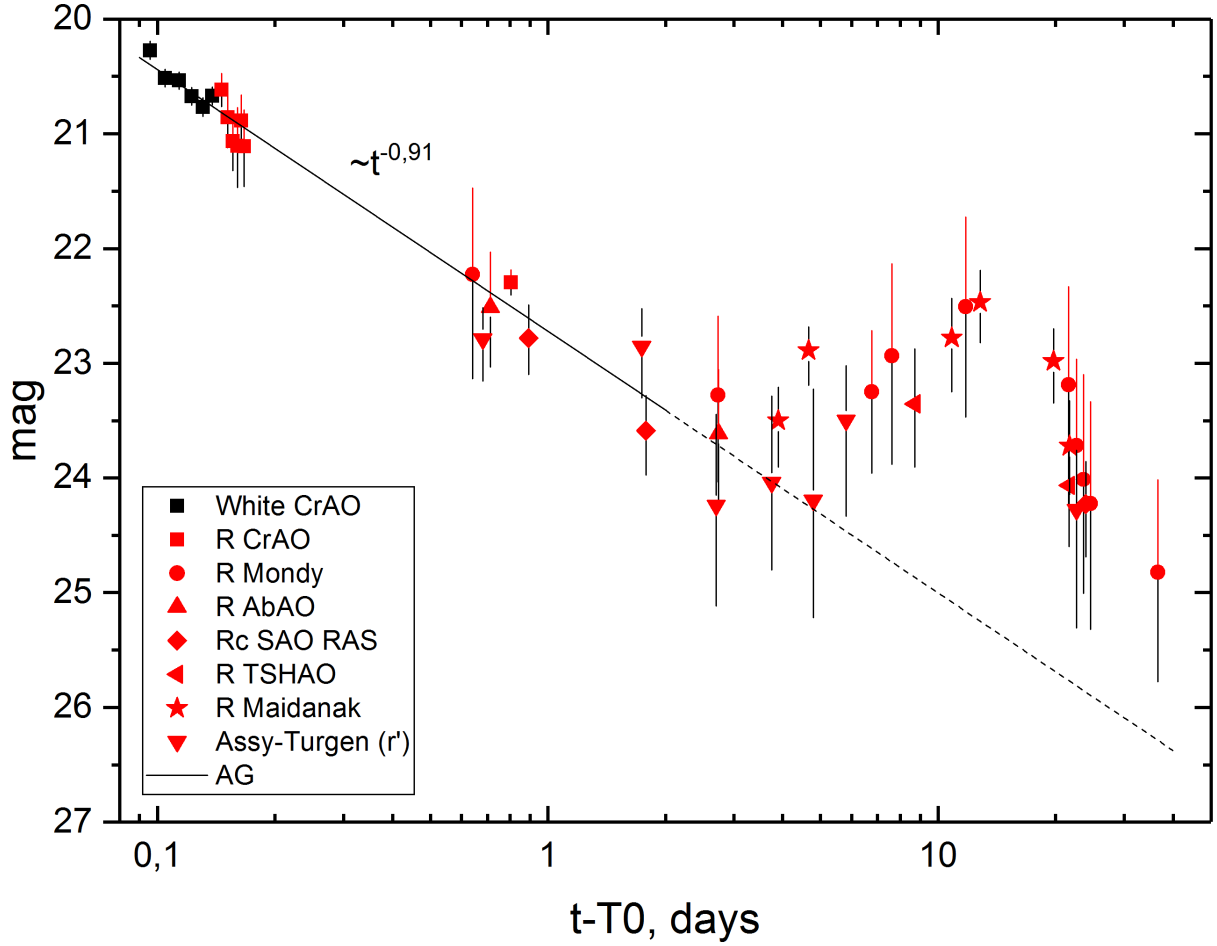




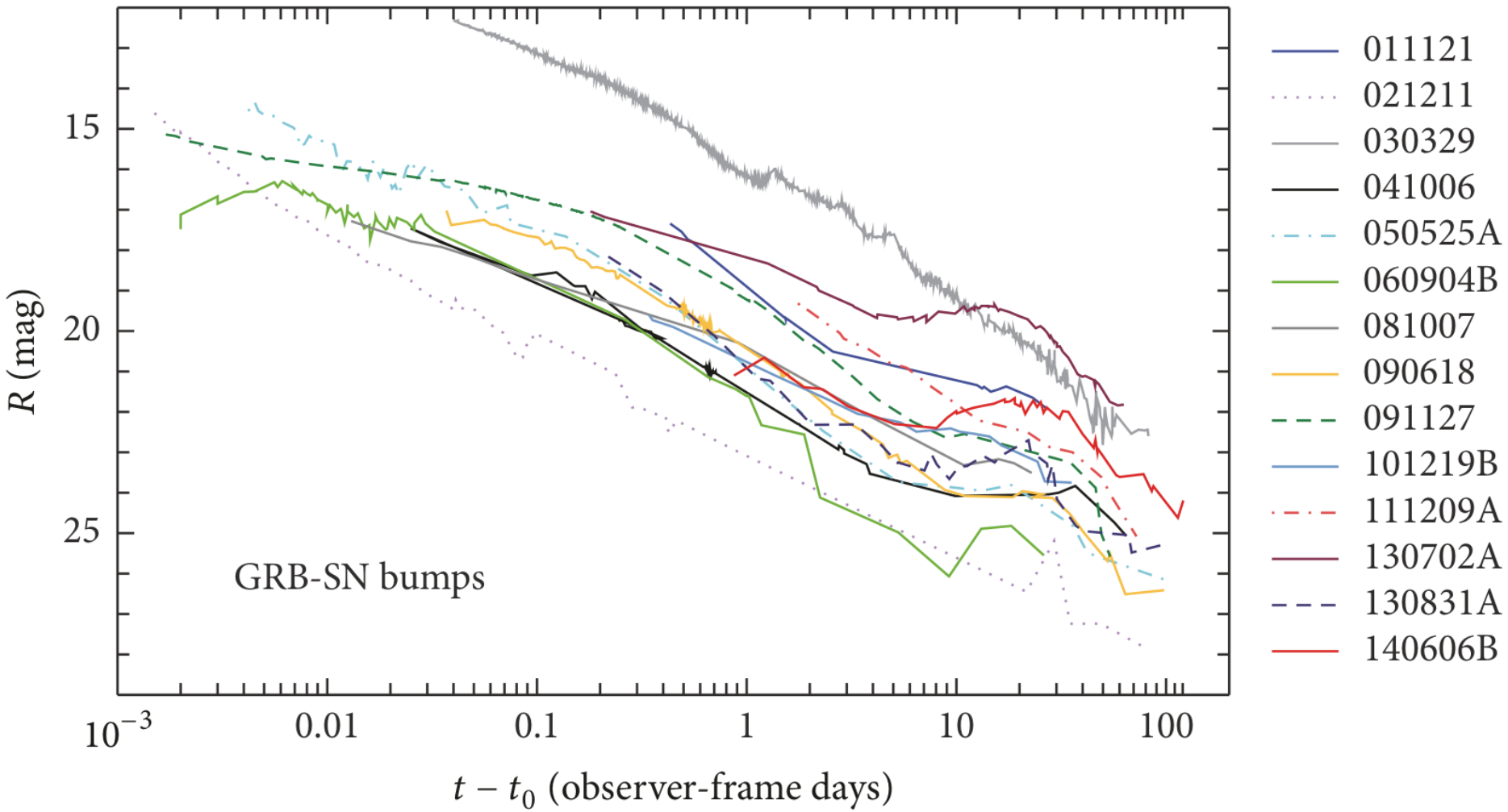


Ruffini et al. (2018) ApJ 852, 53

GRB 201015A optical afterglow light curve



Pozanenko et al. (2020) GCN, id 29033



Cano et al. (2017) AdvanAstr, id 8929054

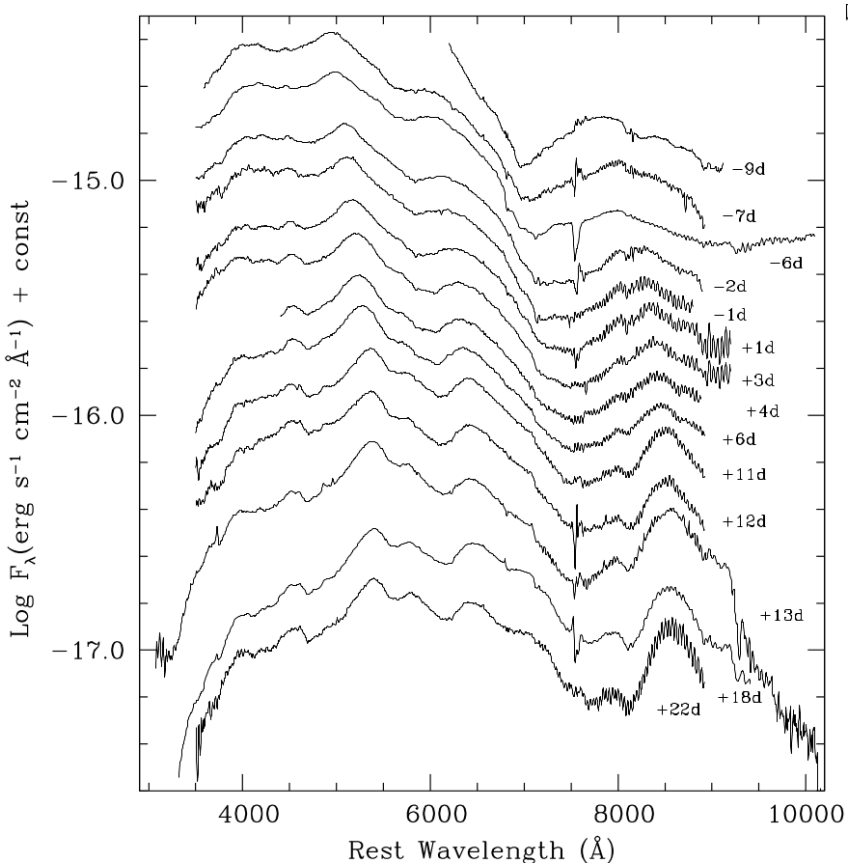
2) spectroscopic identification

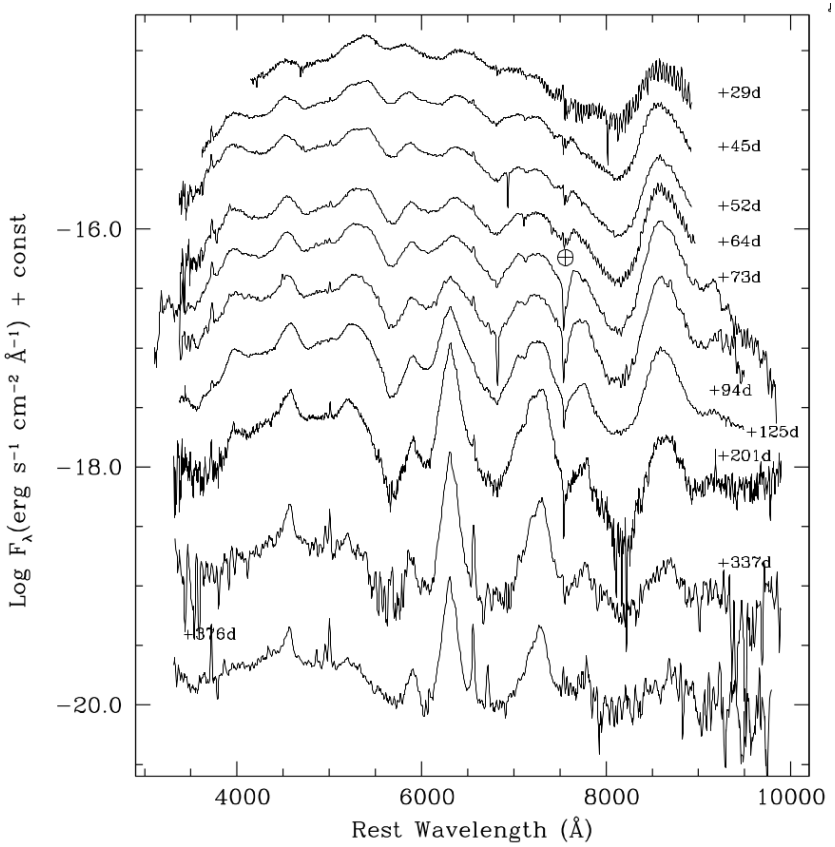
↓

tracks the absorption/emission lines in the spectra

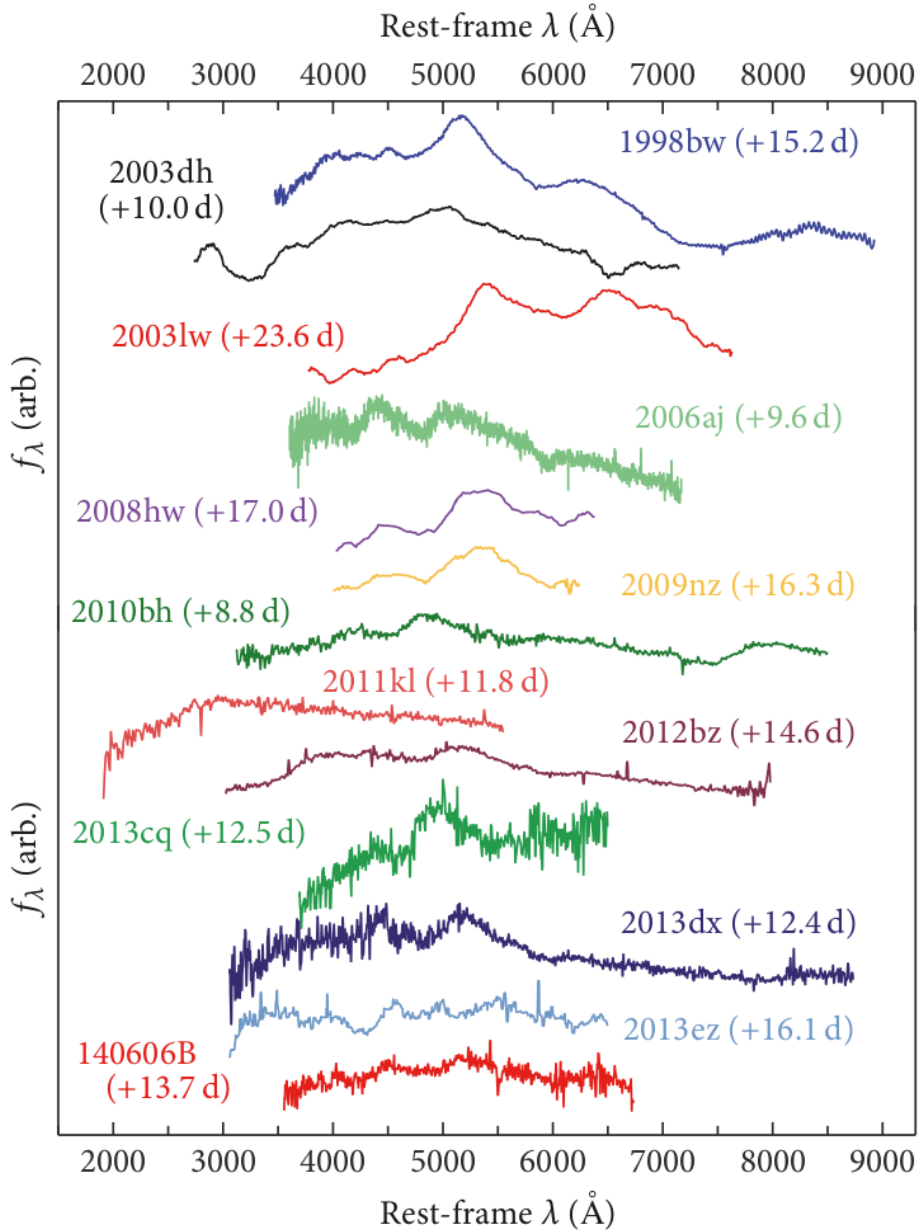
↓

harder to obtain due to needs of the largest telescopes
in order to collect more light in less amount of time

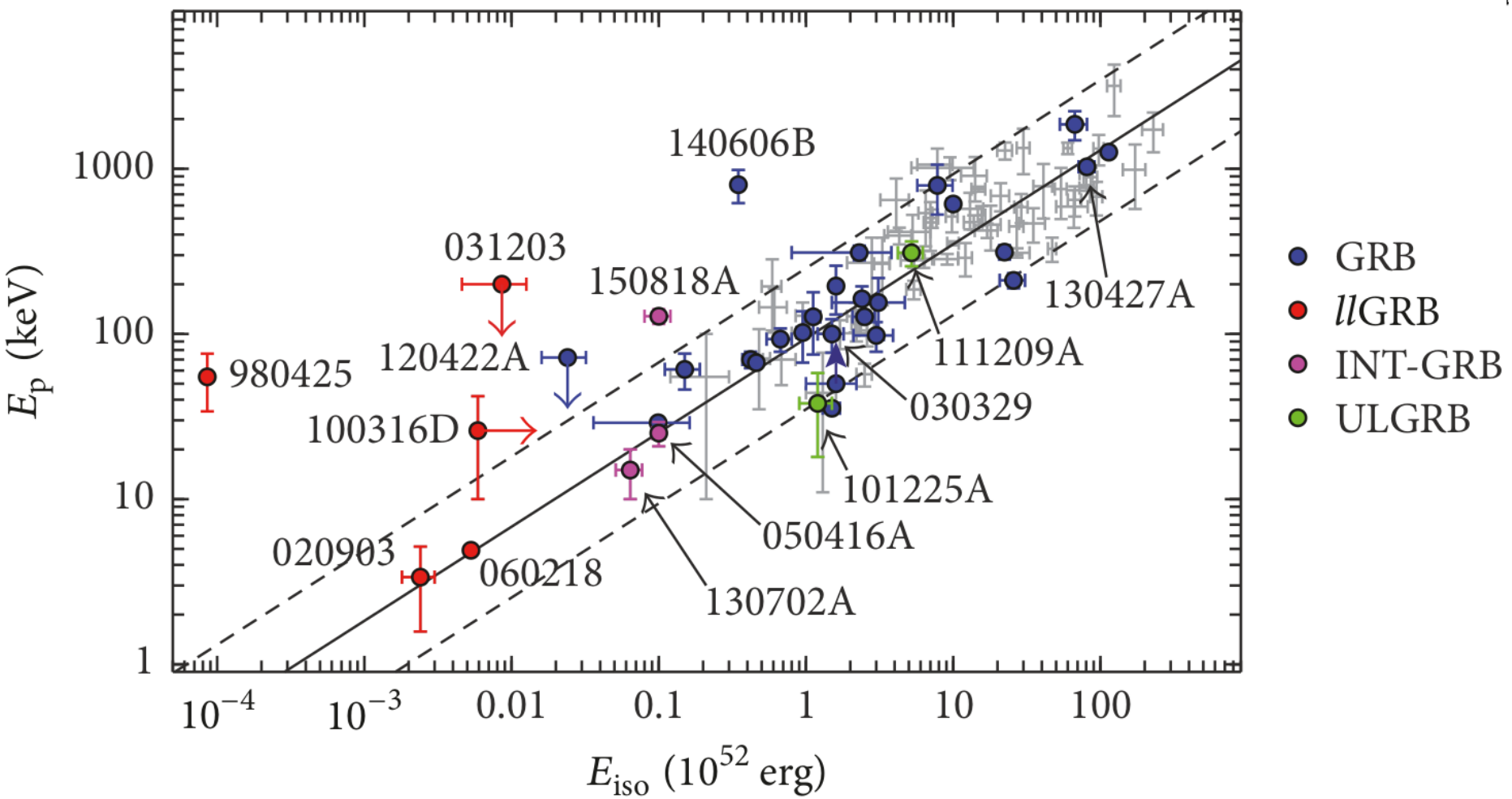




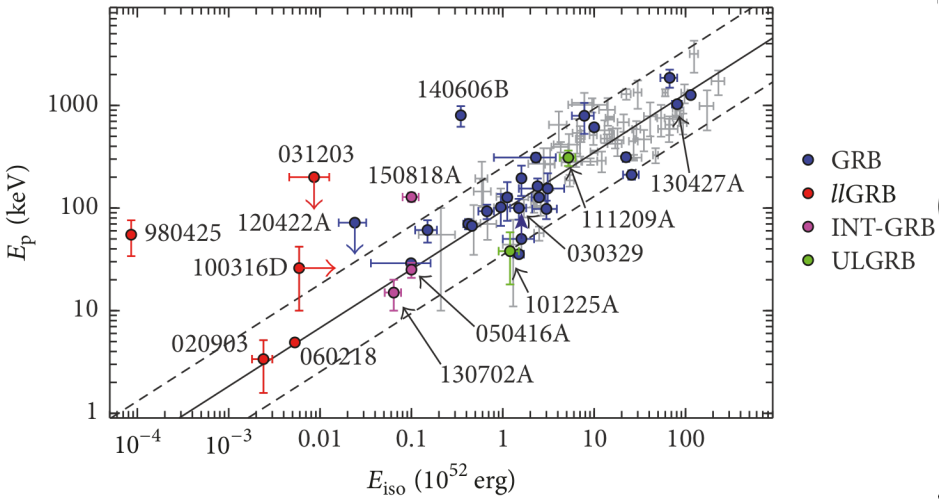
Patat et al. (2001) ApJ 555, 900



Cano et al. (2017) AdvanAstr, id 8929054



Cano et al. (2017) AdvanAstr, id 8929054



(i) *ll*GRB-SNe: GRB-SNe associated with low-luminosity GRBs ($L_{\gamma,\mathrm{iso}} < 10^{48.5}$ erg s^{-1}).

(ii) INT-GRB-SNe: GRB-SNe associated with intermediate-luminosity GRBs ($10^{48.5} < L_{\gamma,\mathrm{iso}} < 10^{49.5}$ erg s^{-1}). (Not to be confused with intermediate-duration GRBs, i.e., those with durations of 2–5 s [50–52].)

(iii) GRB-SNe: GRB-SNe associated with high-luminosity GRBs ($L_{\gamma,\mathrm{iso}} > 10^{49.5}$ erg s^{-1}).

(iv) ULGRB-SNe: ultra-long-duration GRB-SNe, which are classified according to the exceptionally long duration of their γ-ray emission (~10^4 seconds [53, 54]) rather than on their γ-ray luminosities.

Cano et al. (2017) AdvanAstr, id 8929054

a word on GRB-SN phenomenology

why is it interesting to study?

how can we improve it?

You reasonably expect a small sample*

However a deeper study of GRBs associated with SNe
can be quite interesting case by its own.

After all it can turn to be ubiquitous,
i.e., present in every long (?) GRB we detect

and indeed, it is a small sample to compare with whole GRB population

1. GRB background

2. Methods
   - GRB-SN sampling
   - GRB-SN sample
   - What is interesting in GRB-SN population?

3. Results & Discussion

Sampling:

GRB-SN = pre-Fermi + Fermi era

60 (ph+sp) = 30 + 30

We cross-correlate information from:

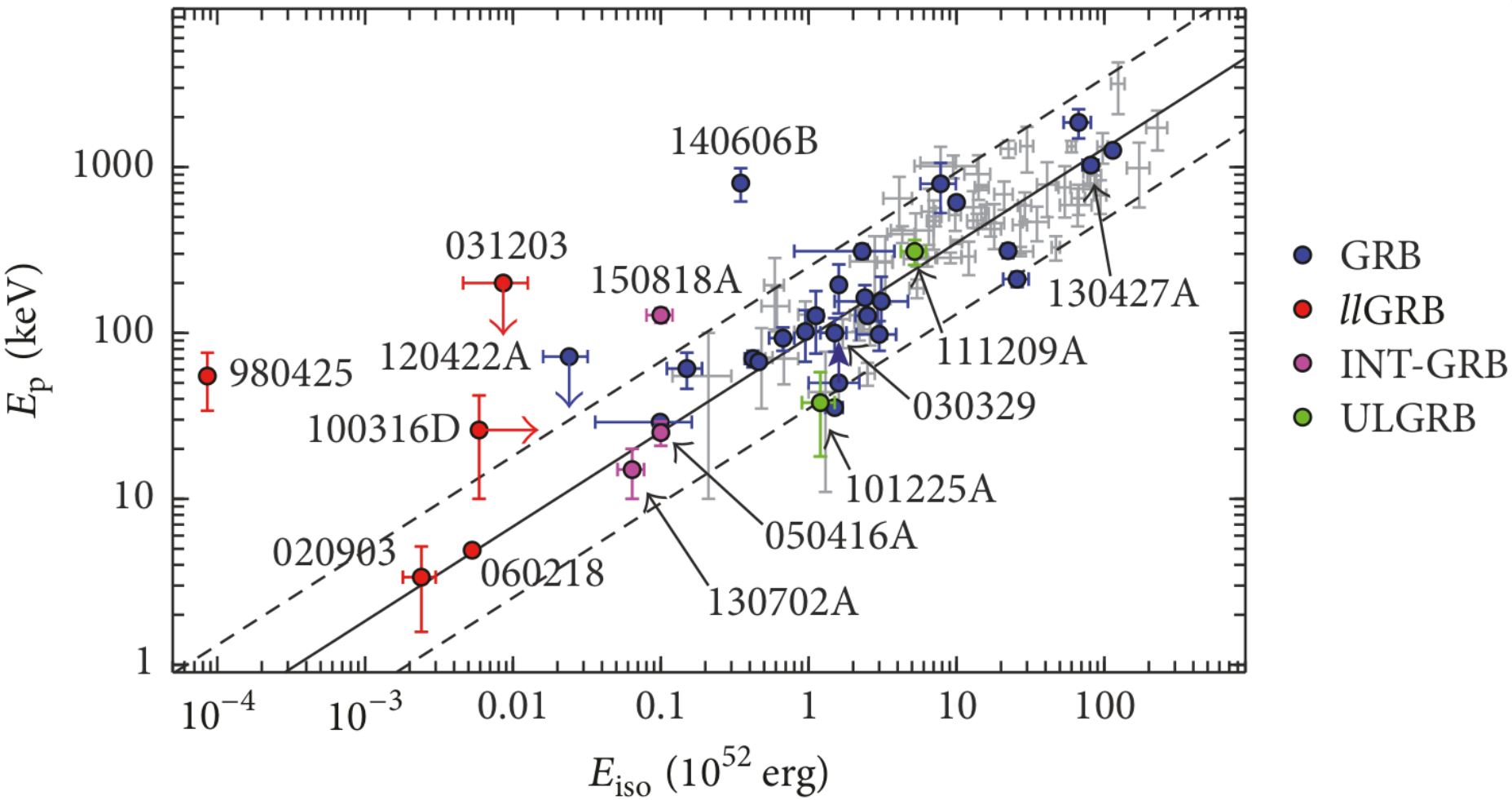
- catalogues on GRBs detected by *Fermi*-GBM
- catalogues on GRBs detected by *Fermi*-LAT
- GCN circulars (since the first GRB-SN association)
- Big table on GRB data by Dr. Greiner
- GRBweb catalogue by Dr. Coppin
- Transient Name Server website
- Simbad Strasbourg database
- + dozens of articles on GRB-SN

60 objects of GRB-SN sample

GRB	SN	Redshift
201015A	bump	0.4260
200826A*	AT2020scz	0.7481
181201A	bump	0.4500
171010A	bump?	0.3285
161219B	2016jca	0.1475
150818A	bump	0.2820
150518A	bump	0.2560
140606B	bump	0.3840
130831A	2013fu	0.4790
130215A	2013ez	> 0.597
120729A	bump	0.8000
120714B	2012eb	0.3984
120422A	2012bz	0.2825
111228A	bump	0.7140
...	...	...
...	...	...

- 30 GRB-SN occurred within *Fermi* era (since mid-2008)
- 30 GRB-SN occurred in pre-*Fermi* era (since 1998)

What is interesting in GRB-SN sample?

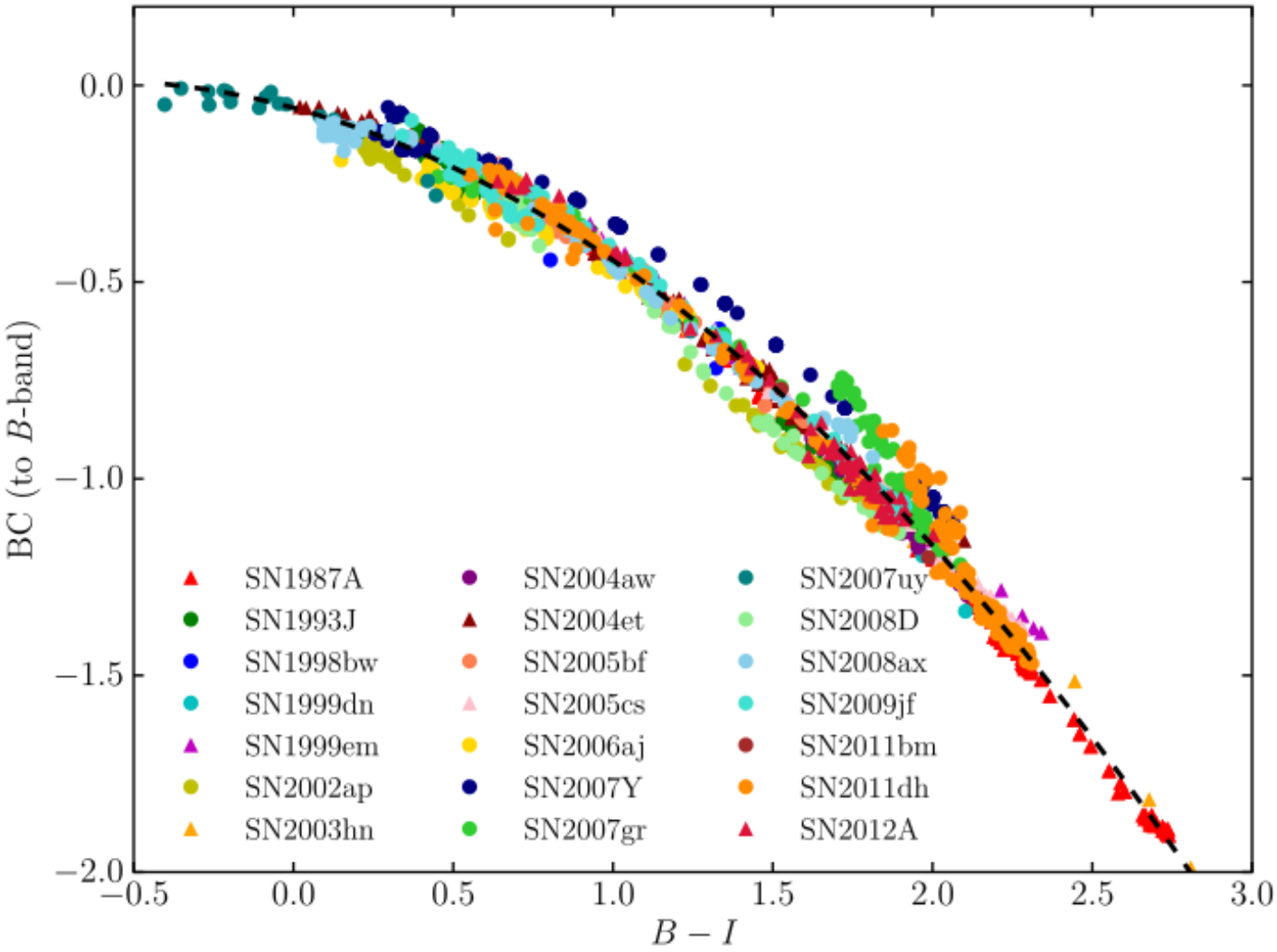


Cano et al. (2017) AdvanAstr, id 8929054

What else should be done for the reduction of data?

We convert photometric values obtained in different filters into bolometric units

Applying Bolometric Corrections

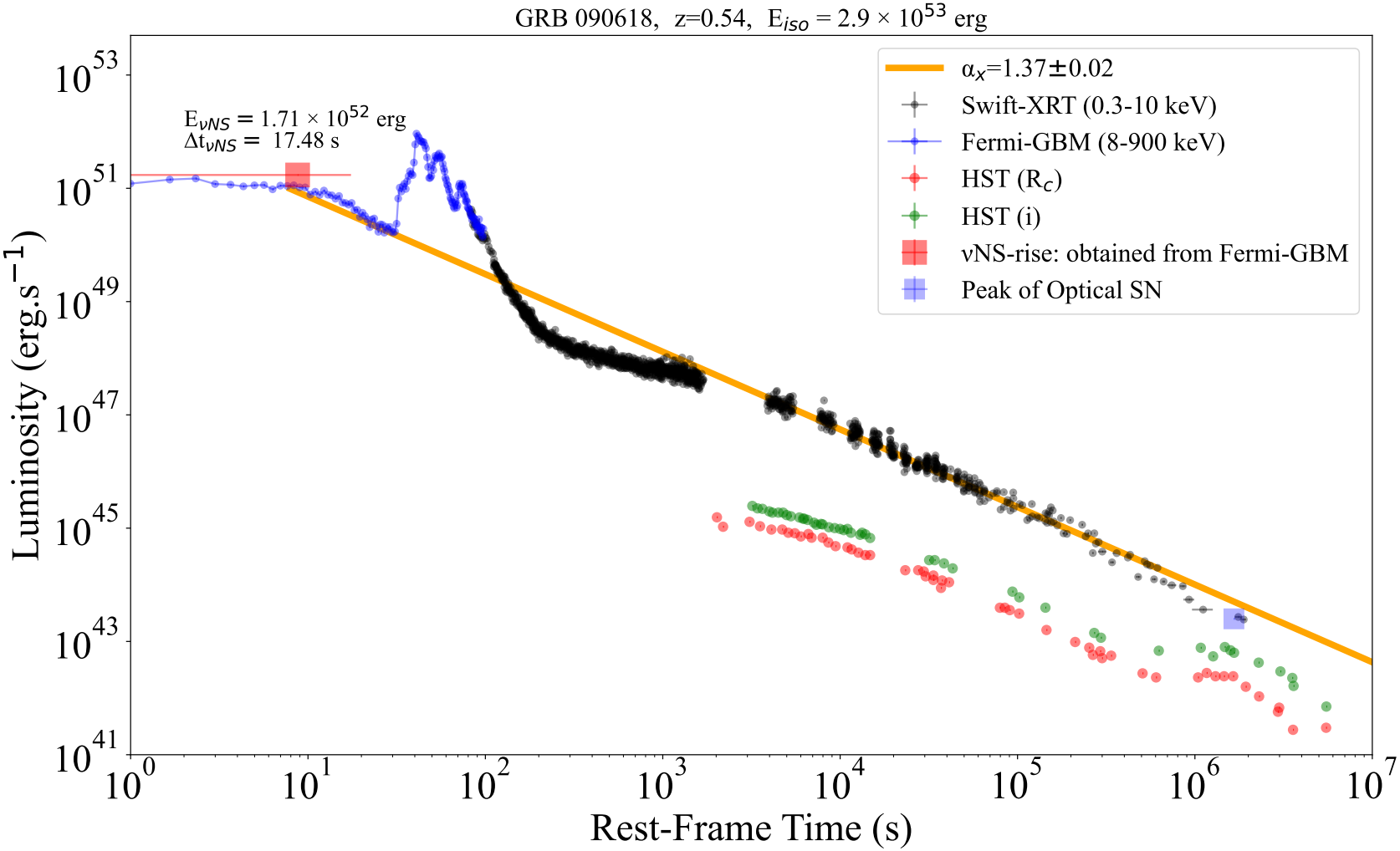


Lyman et al. (2014) MNRAS 437, 3848

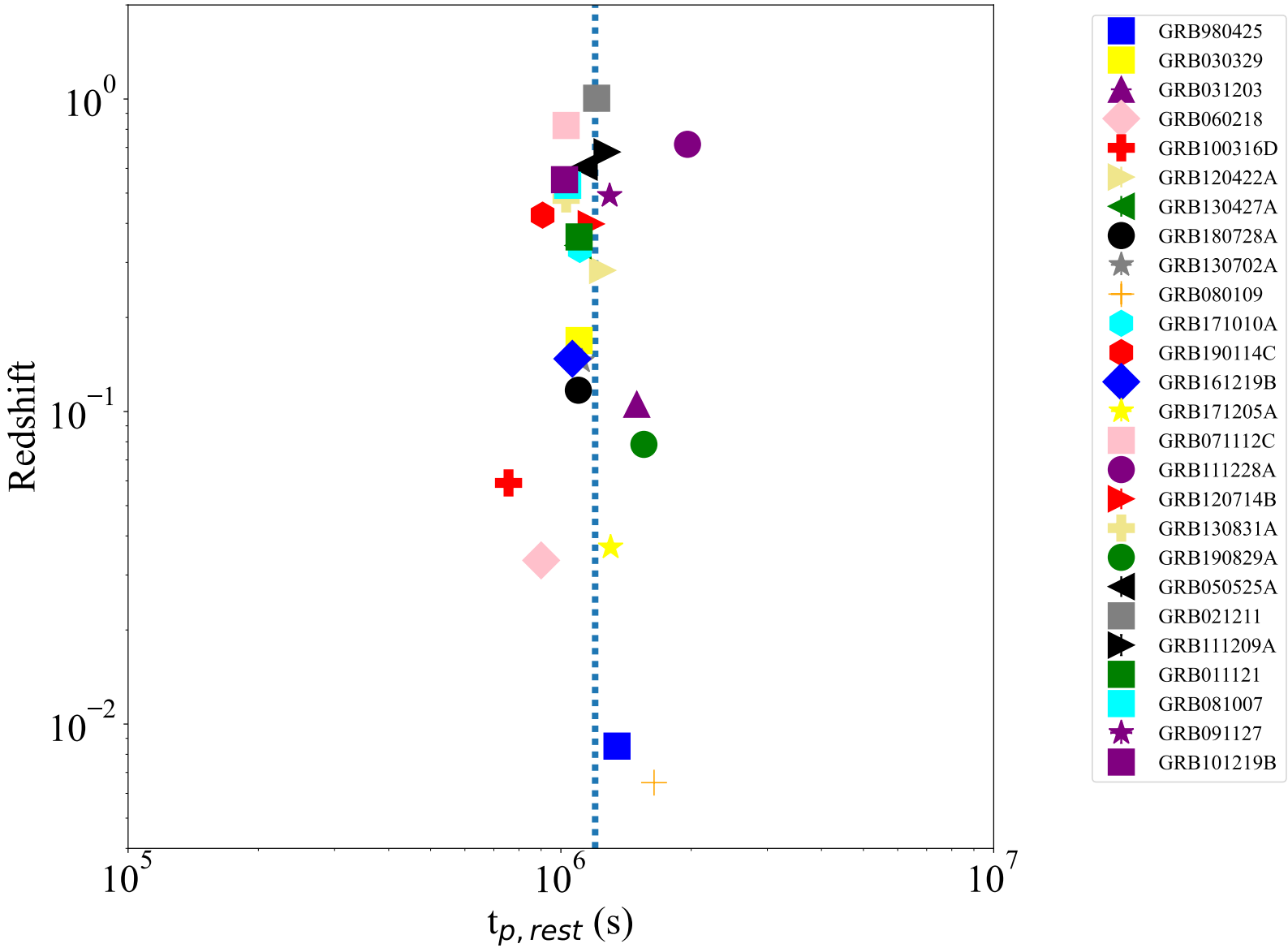
1 GRB background

2 Methods

3 Results & Discussion
- GRB-SN search for correlation



Ruffini et al. (2021) in preparation



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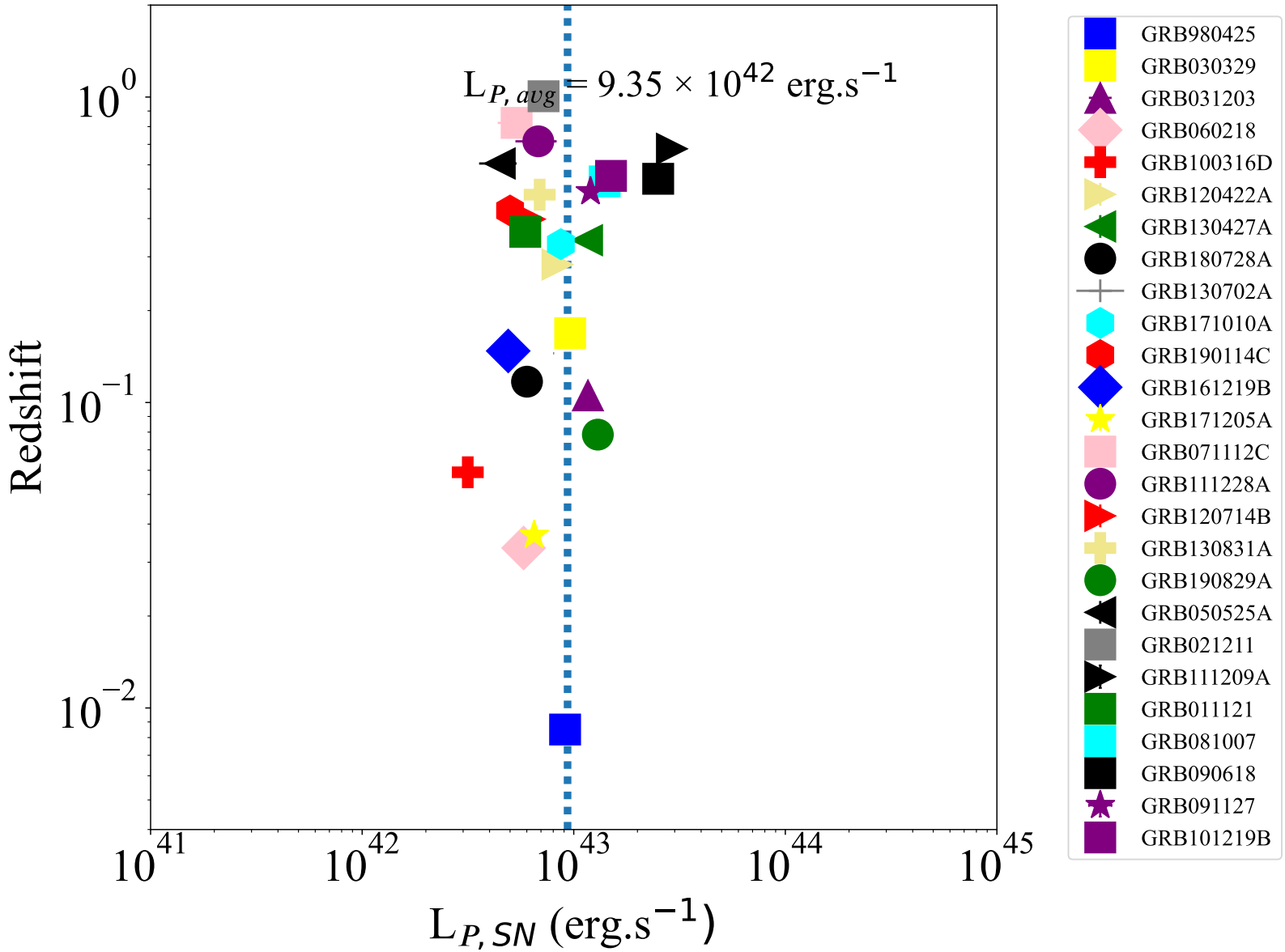

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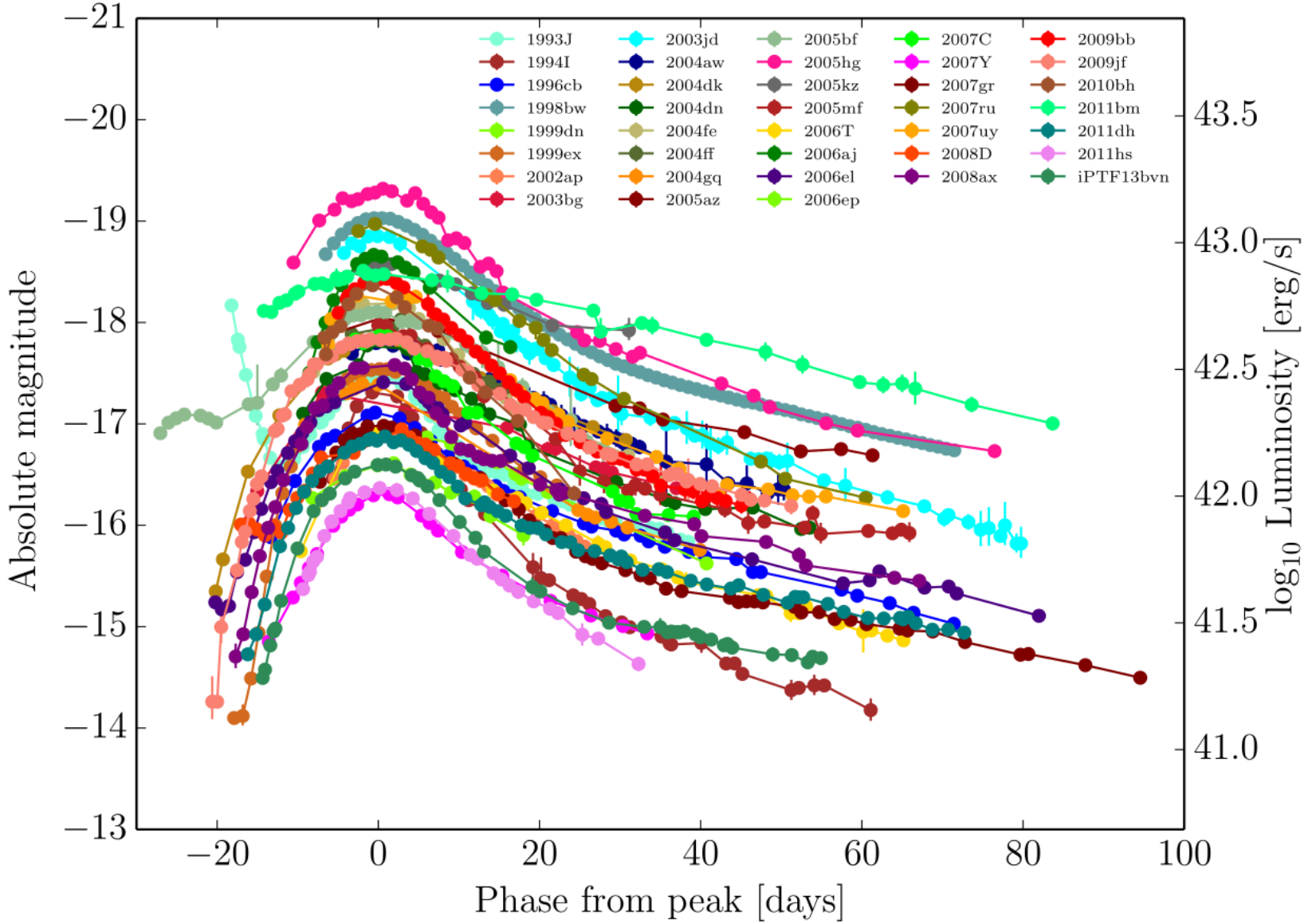
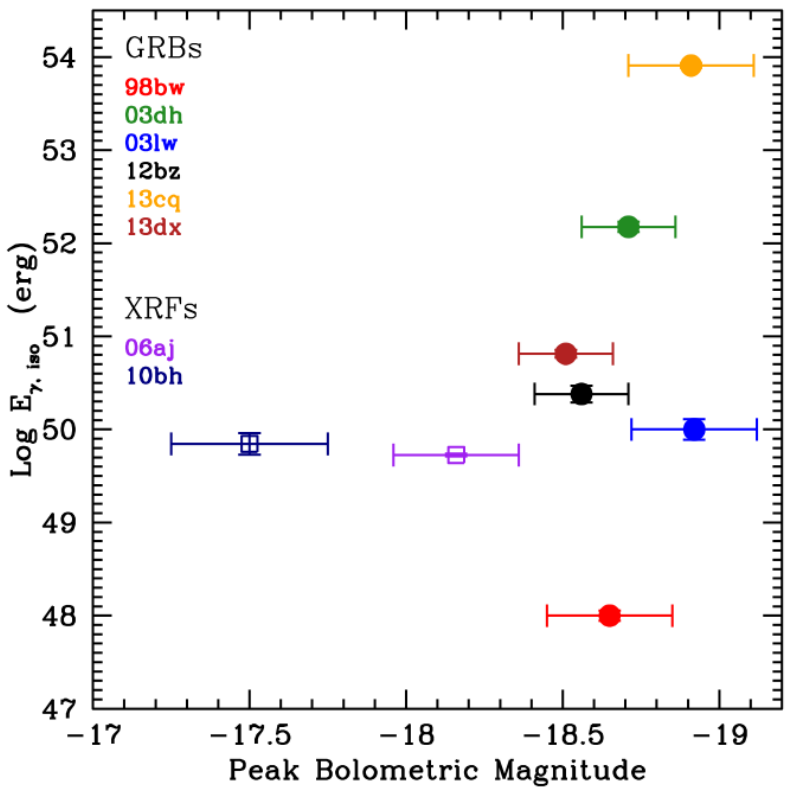
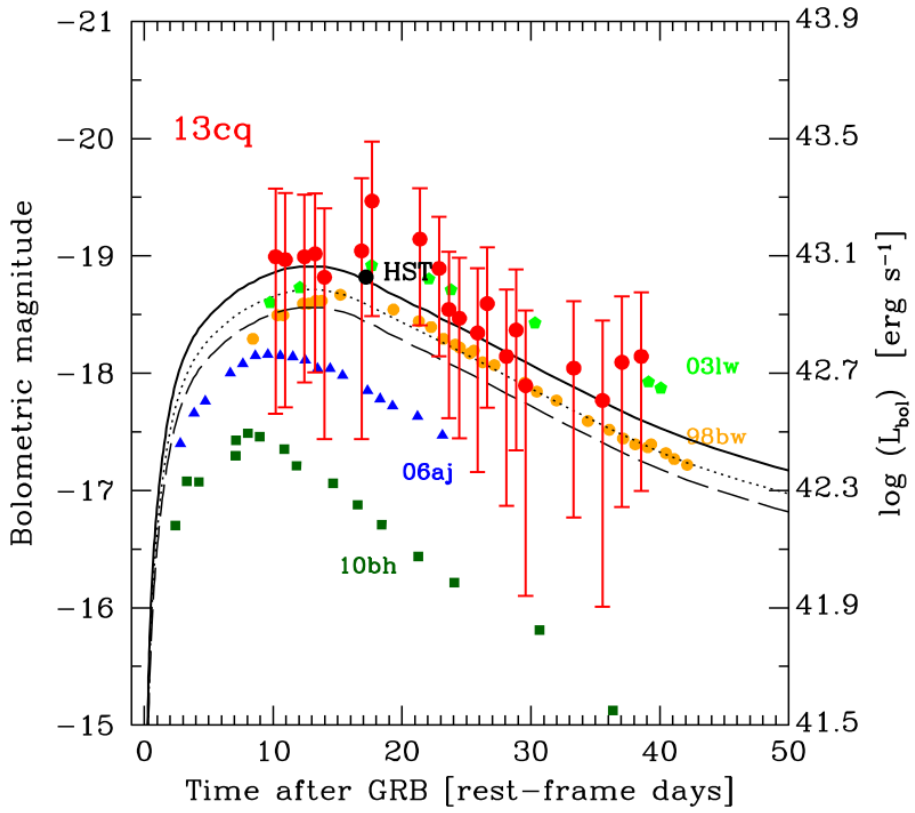
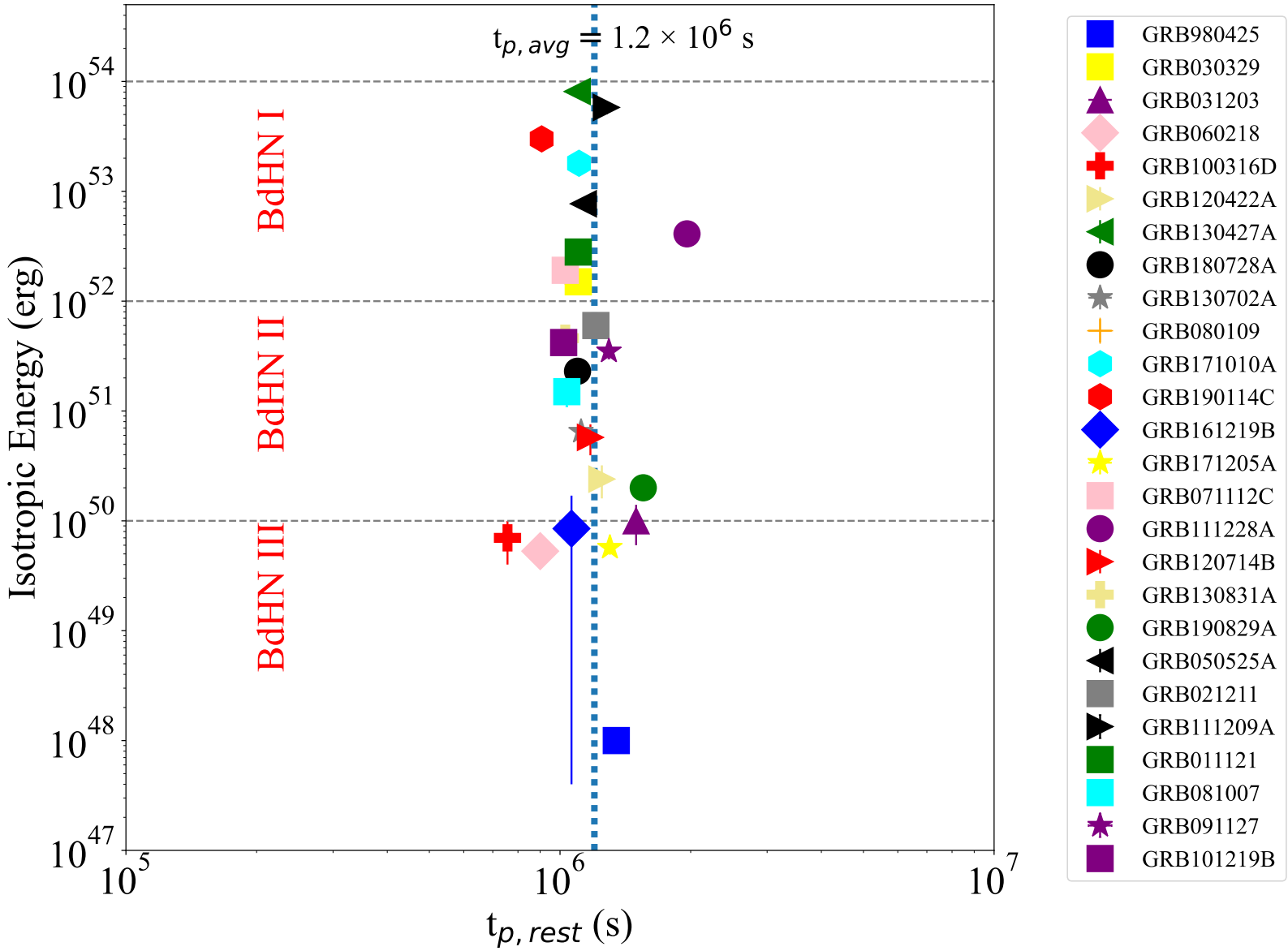


Lyman et al. (2016) MNRAS 457, 328





Melandri et al. (2014) A&A 567, A29



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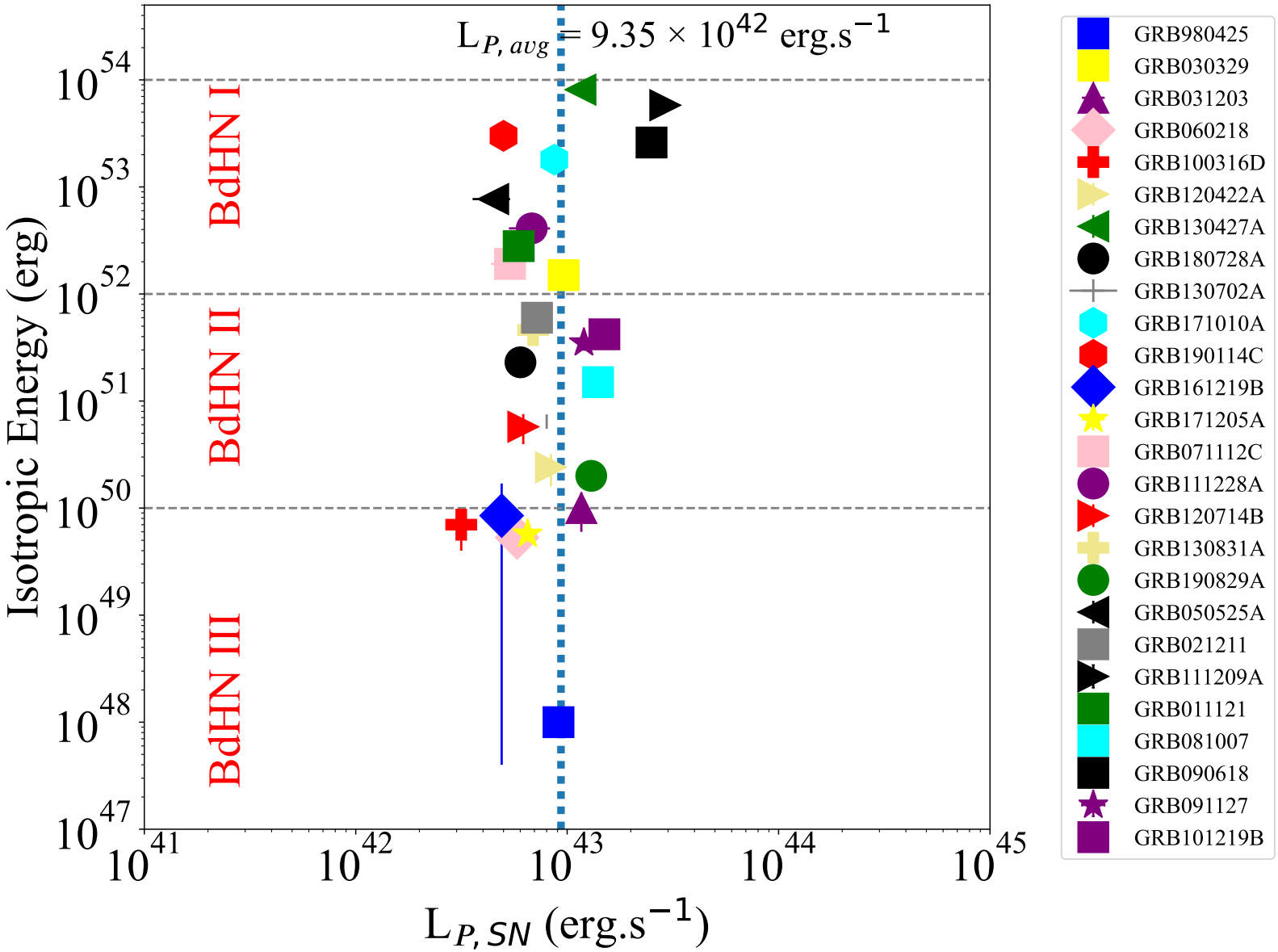

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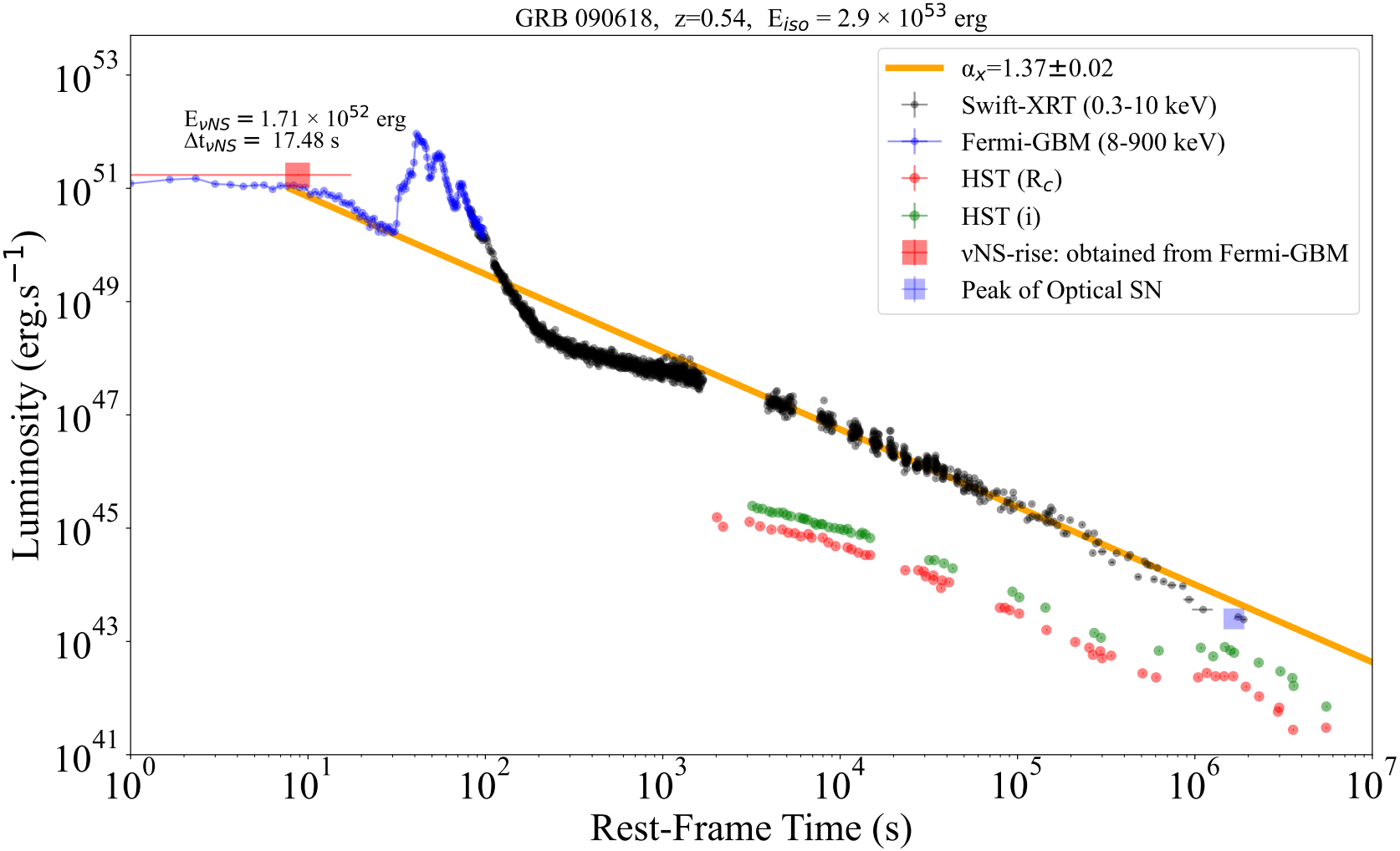

Ruffini et al. (2021) in preparation

GRB-SN: summary

sampling of GRB-SN during the whole era of their optical observation

sub-sampled GRB-SN with good optical data to use in our analysis

photometric data evaluation to get a SN light curve

calculation of SN Luminosity at the peaking time

we see the universality of peaking time for selected SN

we give an interpretation of it within binary nature of progenitors

Questions?

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