# INTRO

# GeV-GRB-SN

compare and contrast

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**Sixteenth Marcel Grossmann Meeting (Virtual)**

Session GB4: **HE & VHE Emission from GRB**s


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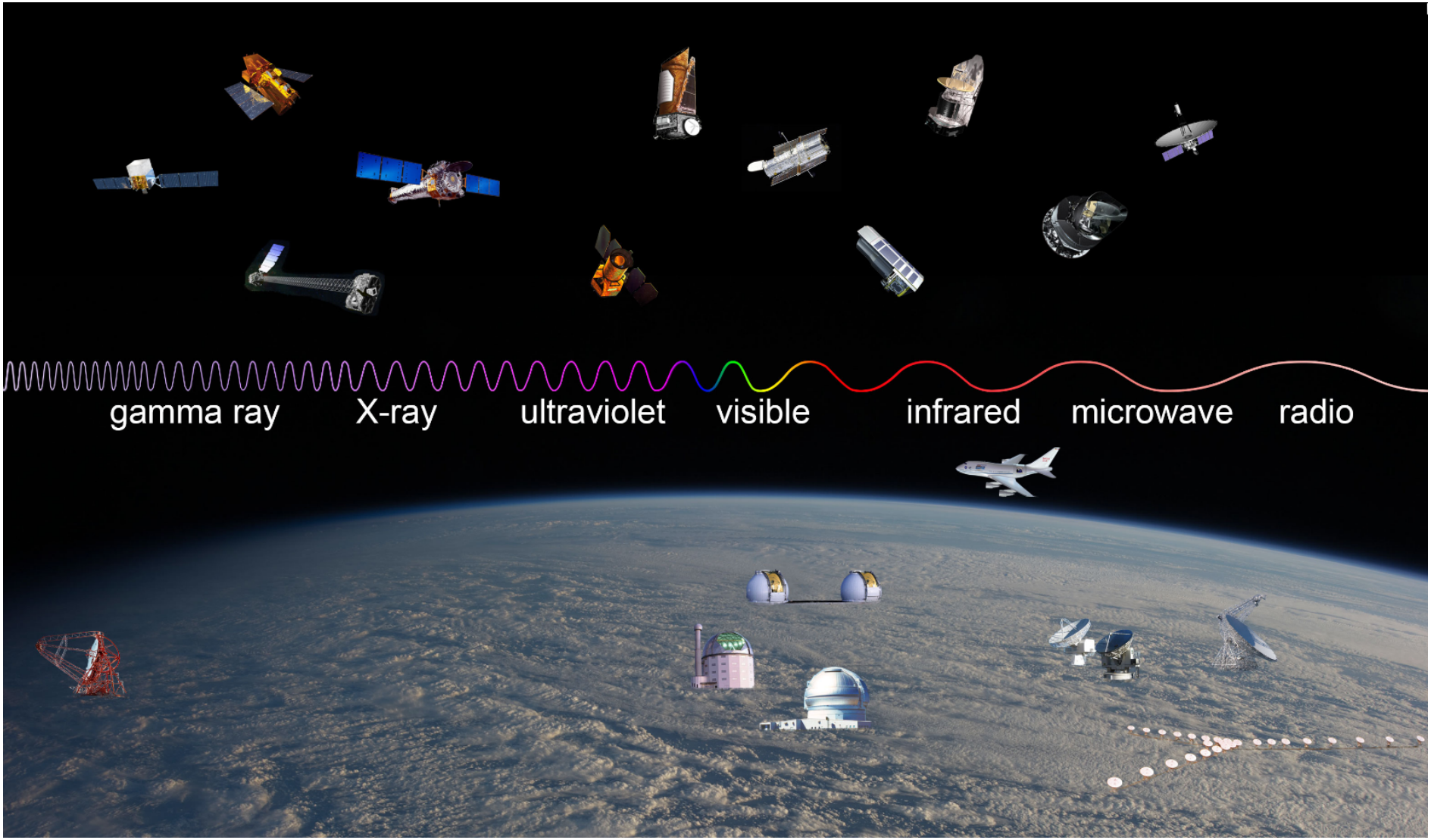
here you need to

**imagine**

your favorite

the most beautiful picture of a GRB you have ever seen

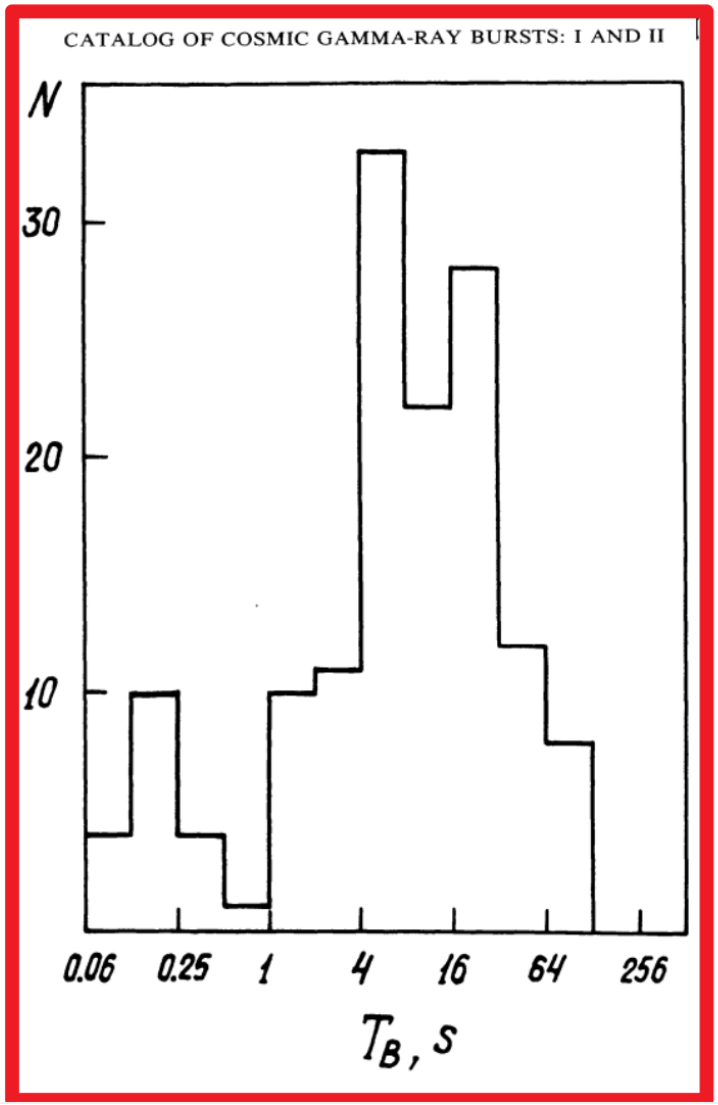
e.g., kilonova GRB 170817A, but I do not insist



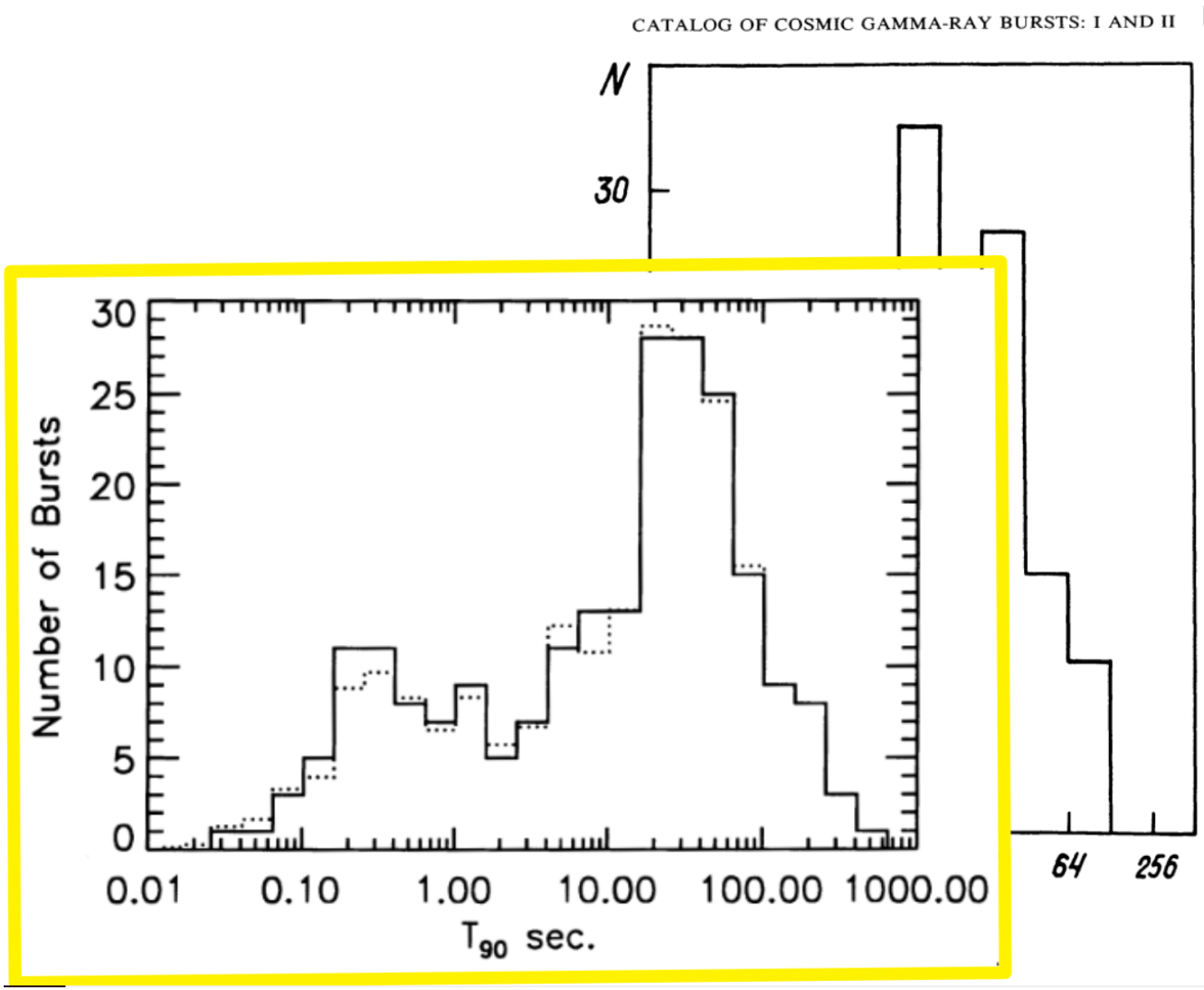

Credit: Observatory images from NASA, ESA (Herschel and Planck), Lavochkin Association (Specktr-R), HESS Collaboration (HESS), Salt Foundation (SALT), Rick Peterson/WMKO (Keck), Germini Observatory/AURA (Gemini), CARMA team (CARMA), and NRAO/AUI (Greenbank and VLA); background image from NASA

phenomenology* of long/short duration

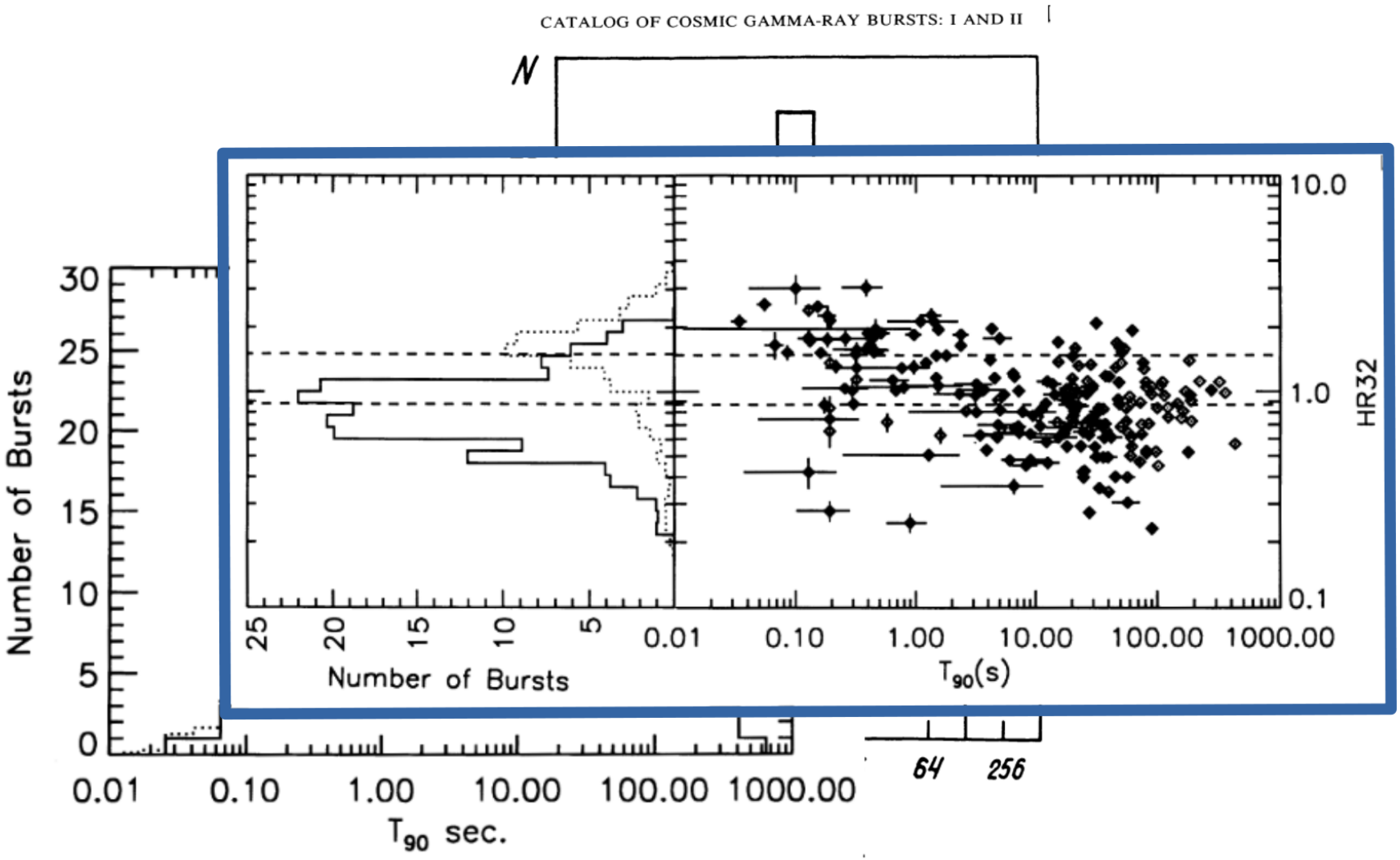
*not anymore, because duration hints on the progenitors



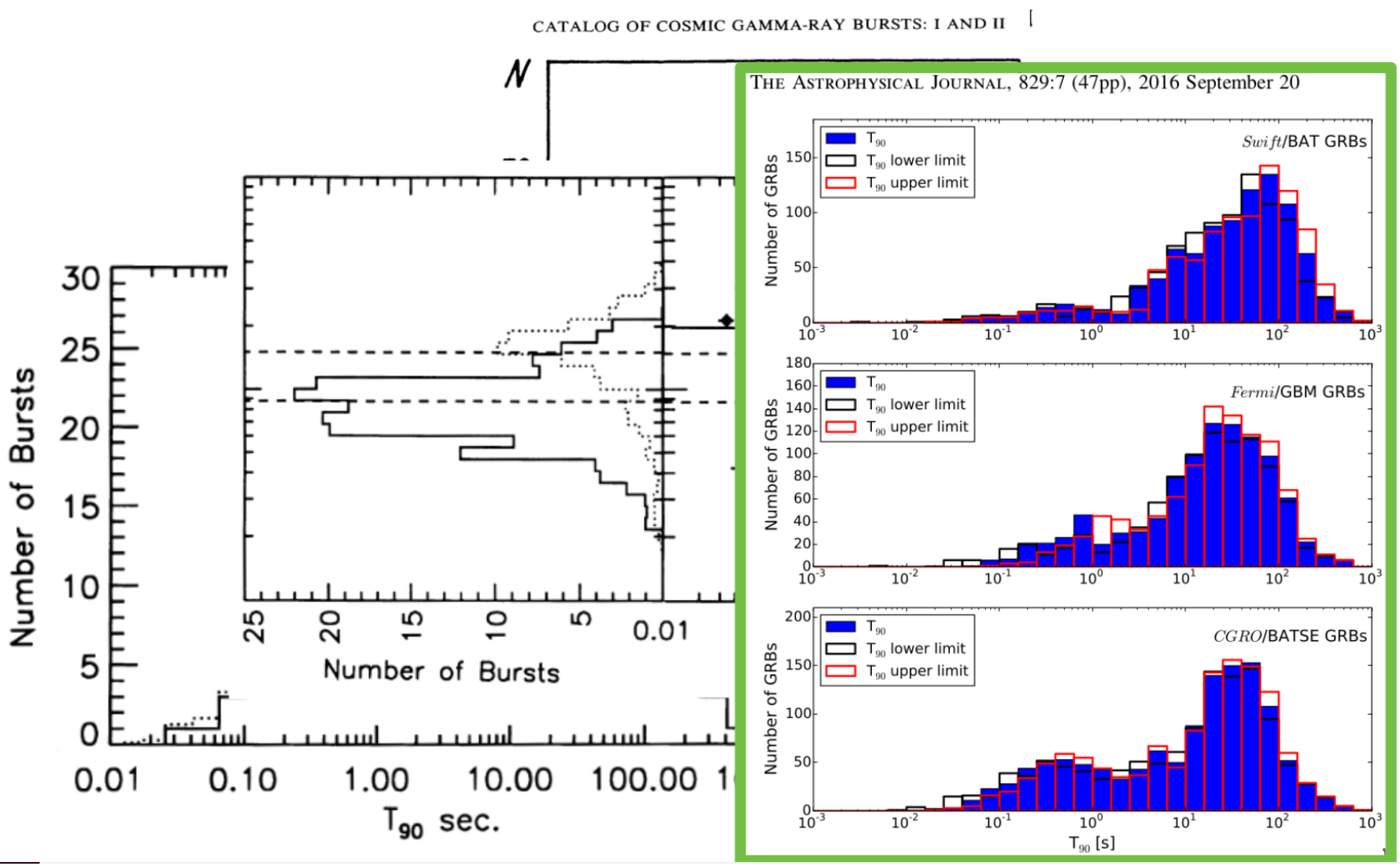

Mazets et al. (1981) ApSS 80, 3



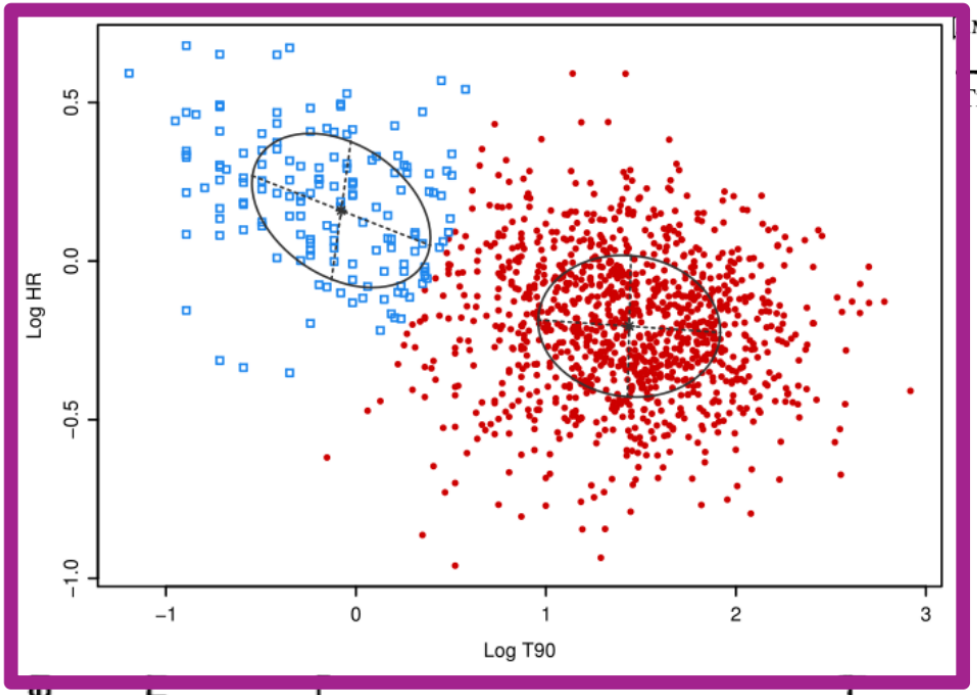

Kouveliotou et al. (1993) ApJL 413, 101

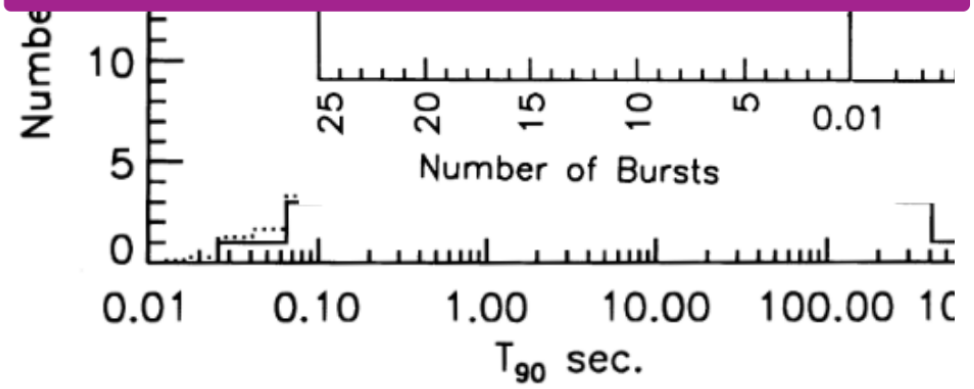



Kouveliotou et al. (1993) ApJL 413, 101



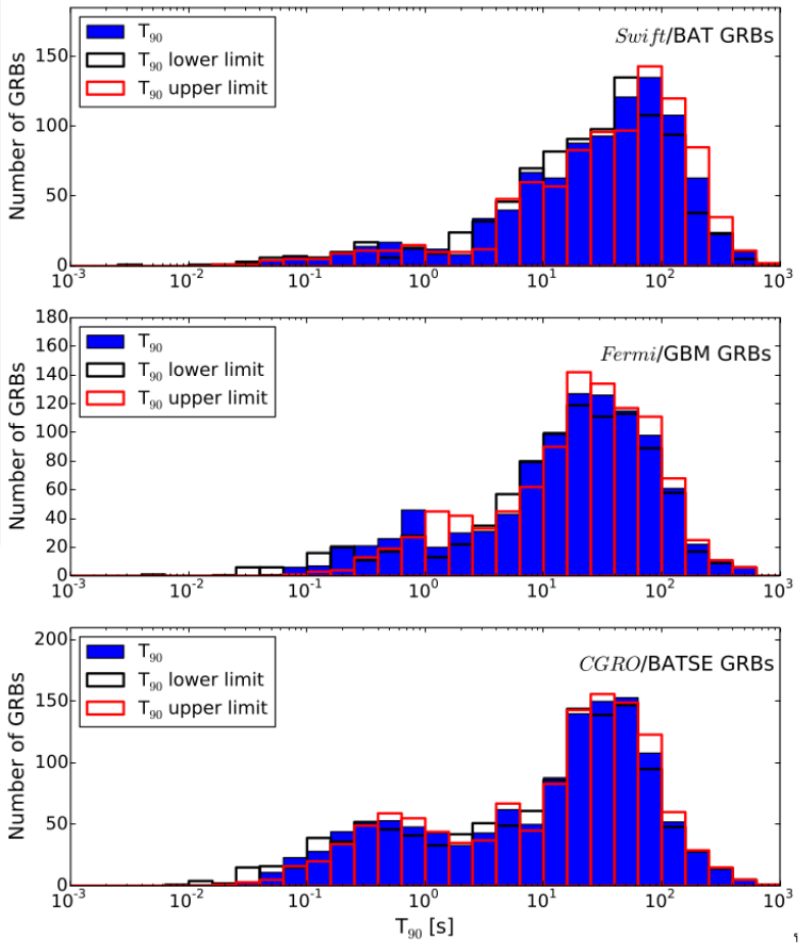

Lien et al. (2016) ApJ 829, 7



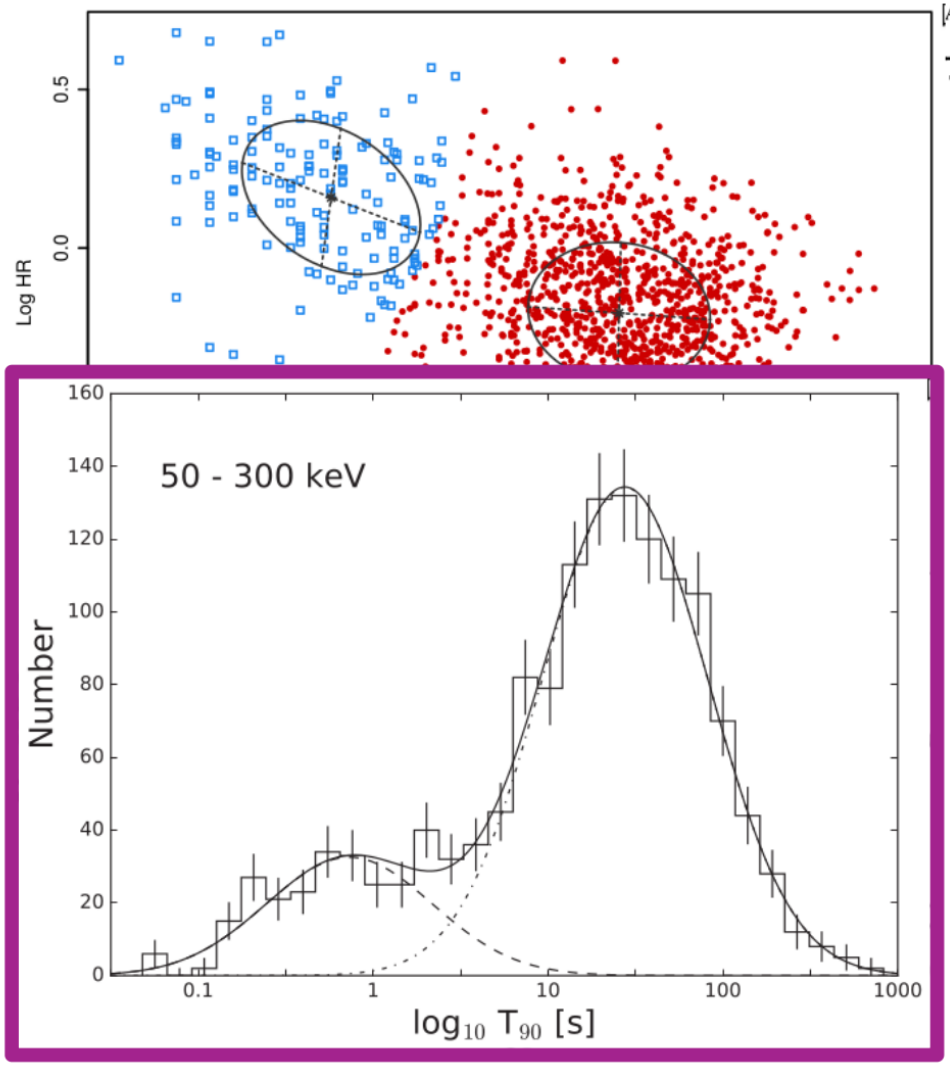




MMA-RAY BURSTS: I AND II

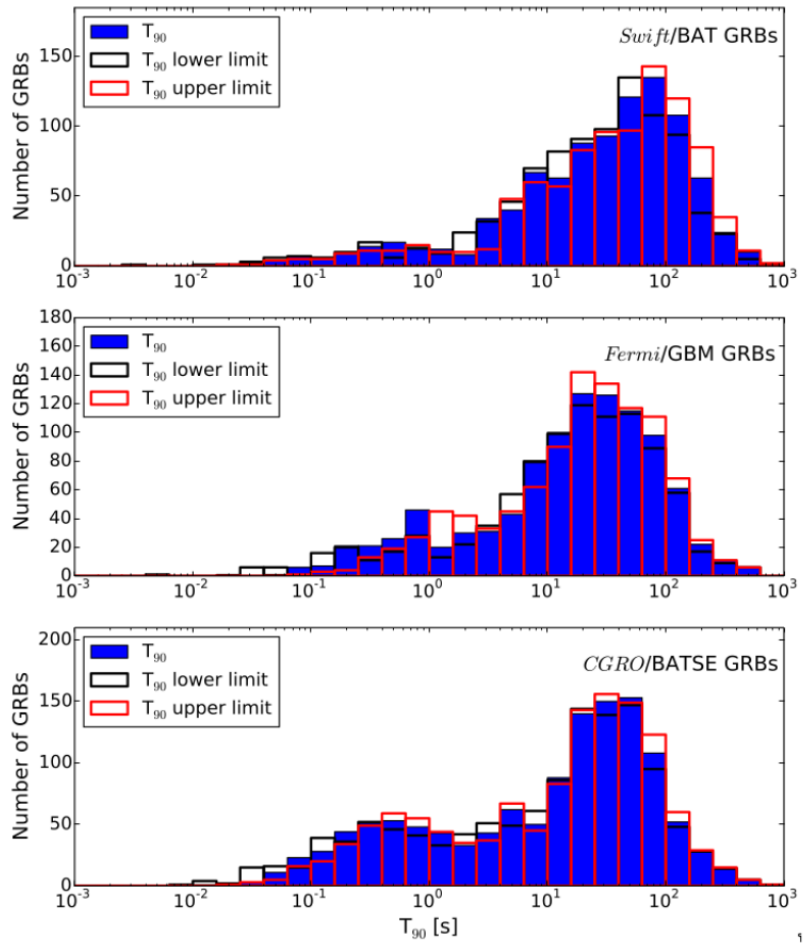
THE ASTROPHYSICAL JOURNAL, 829:7 (47pp), 2016 September 20




Bhat et al. (2016) ApJS 223, 28




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




Bhat et al. (2016) ApJS 223, 28

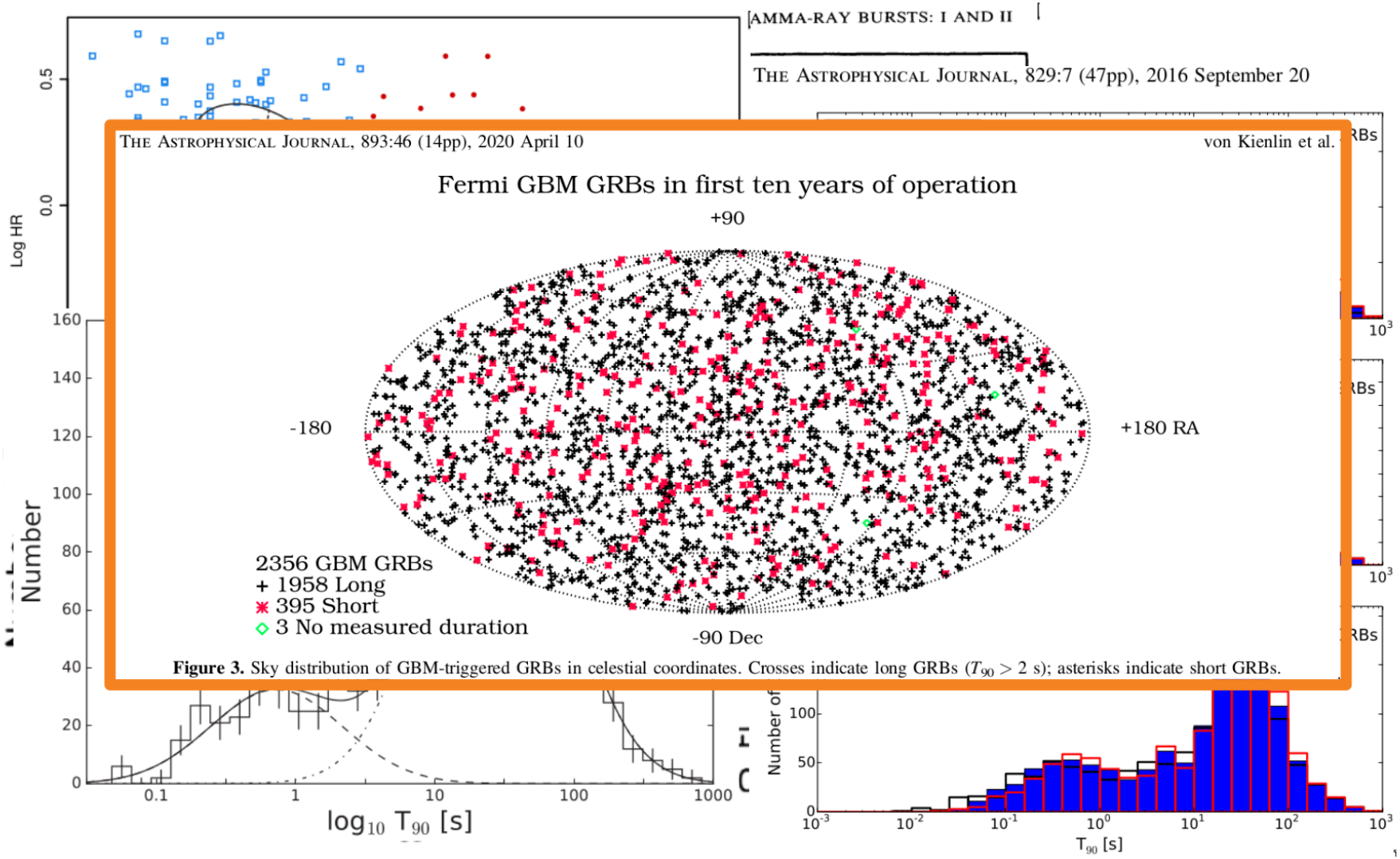



**Figure 3.** Sky distribution of GBM-triggered GRBs in celestial coordinates. Crosses indicate long GRBs ($T_{90} > 2$ s); asterisks indicate short GRBs.

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

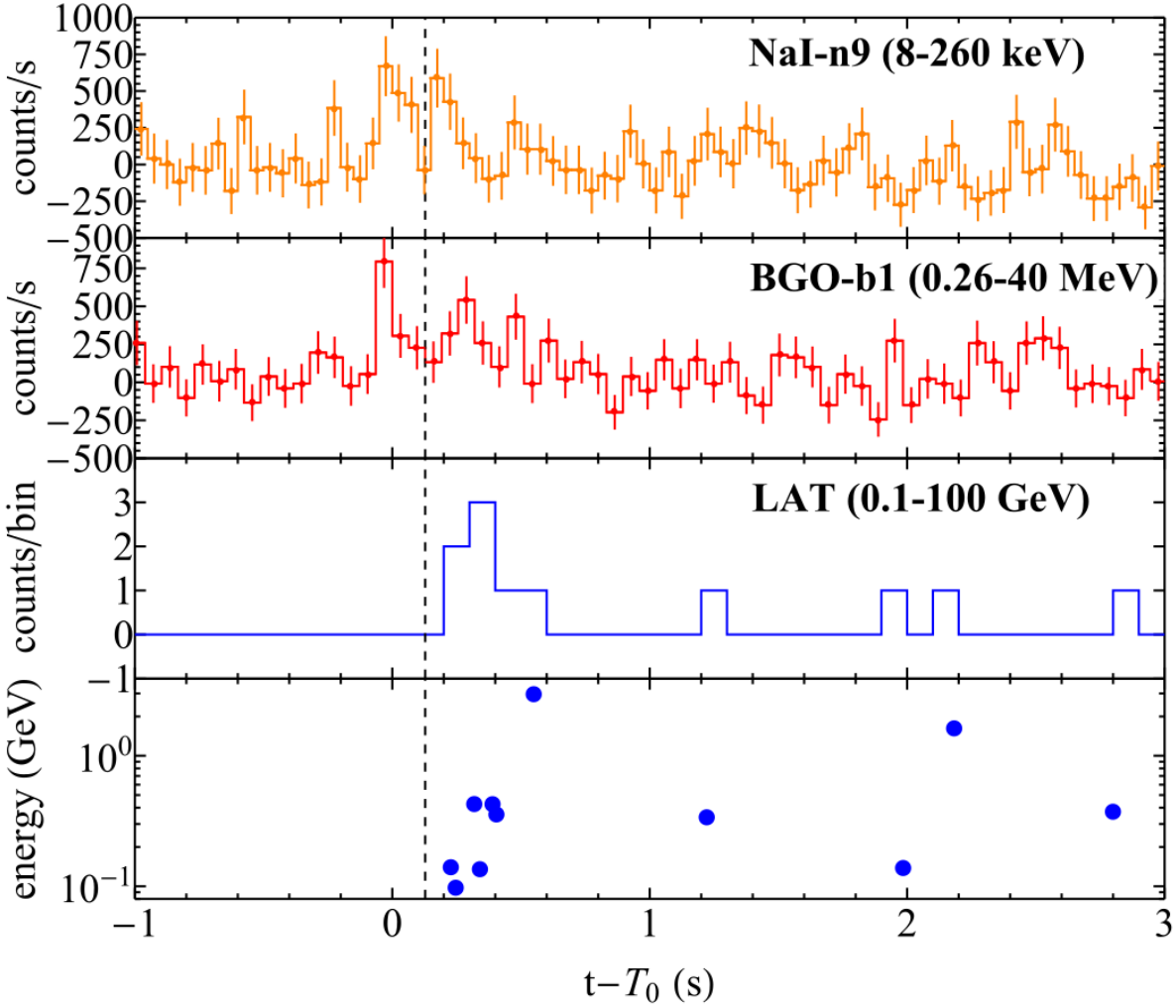
high energy emission (GeV photons)

GRBs detection statistics for *Fermi*-GBM and *Fermi*-LAT

| End time | GBM | $T_{90} < 2$ s. | $T_{90} \geq 2$ s. | LAT | $T_{90} < 2$ s. | $T_{90} \geq 2$ s |
|---|---|---|---|---|---|---|
| July 2011 | 733 | 122 (16.6%) | 611 (83.4%) | 35 (4.8%) | 5 | 30 |
| Dec. 2016 | 1981 | 324 (16.4%) | 1657 (83.6%) | 122 (6.2%) | 13 | 109 |
| Dec. 2017 | 2232 | 366 (16.4%) | 1866 (83.6%) | 141 (6.3%) | 13 | 128 |
| July 2018 | 2367 | 398 (16.8%) | 1969 (83.2%) | 169 (7.1%) | 14 | 155 |

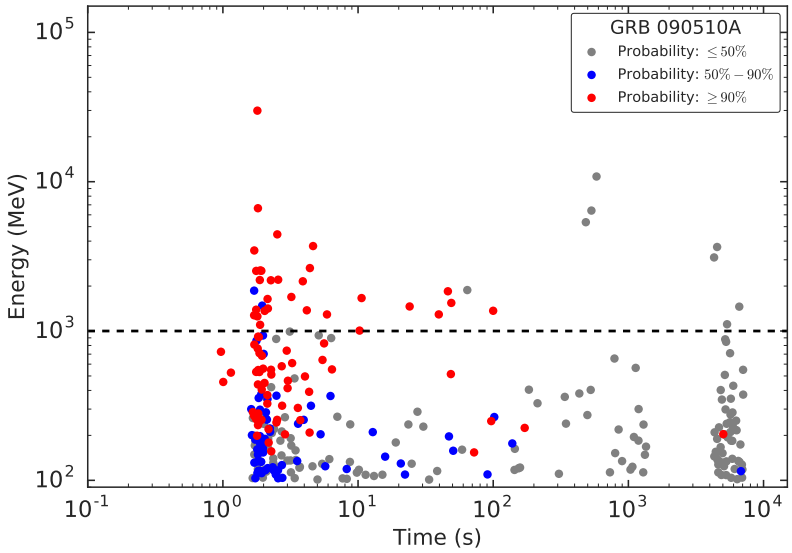
Ajello et al. (2019) ApJ 878, 52 von Kielnin et al. (2020) ApJ 893, 46

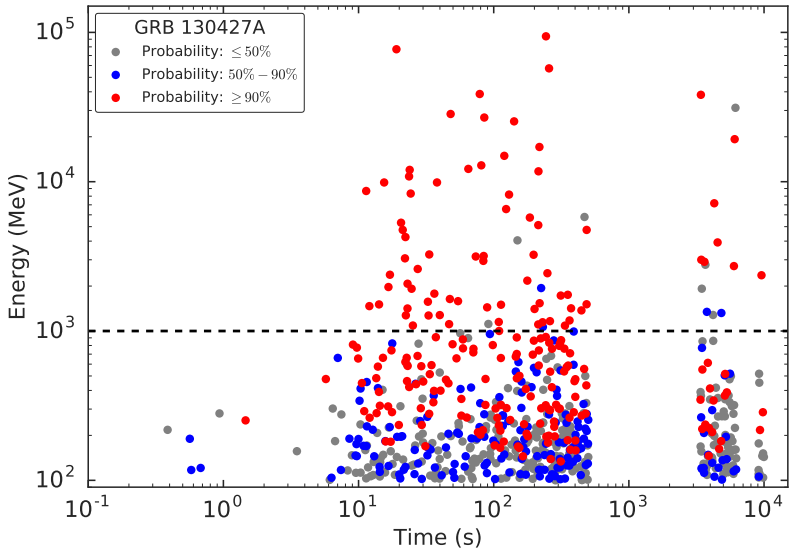
# GRB 081024B: background subtracted light curve and high energy photons




Aimuratov et al. (2017) ApJ 844, 83

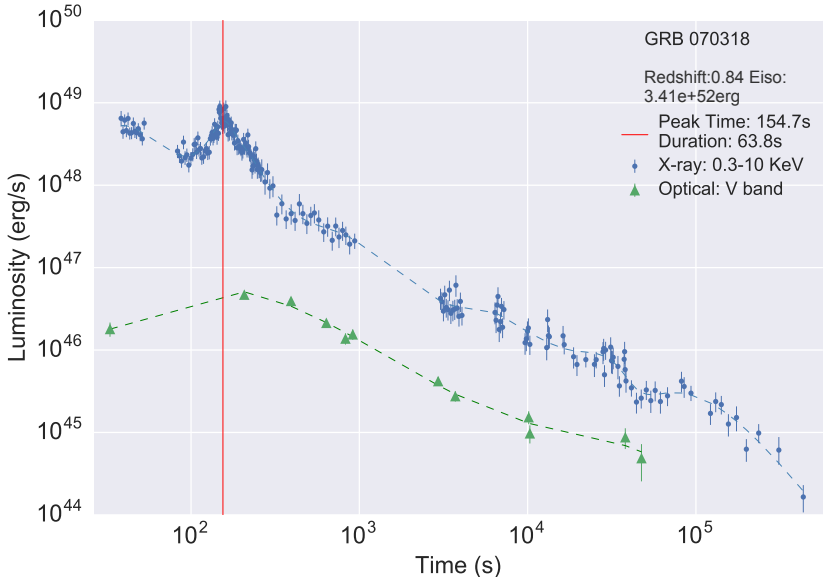
# Photons of GRB 090510A and GRB 130427A in high-energy domain

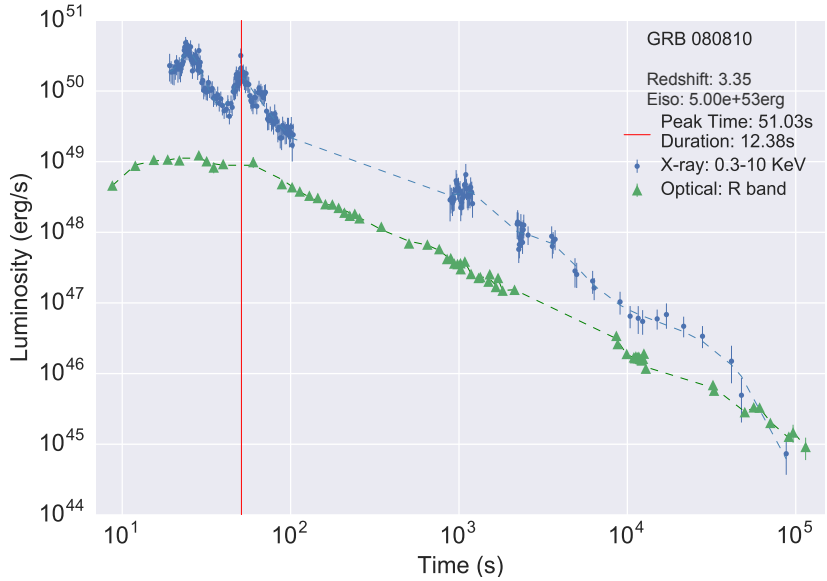


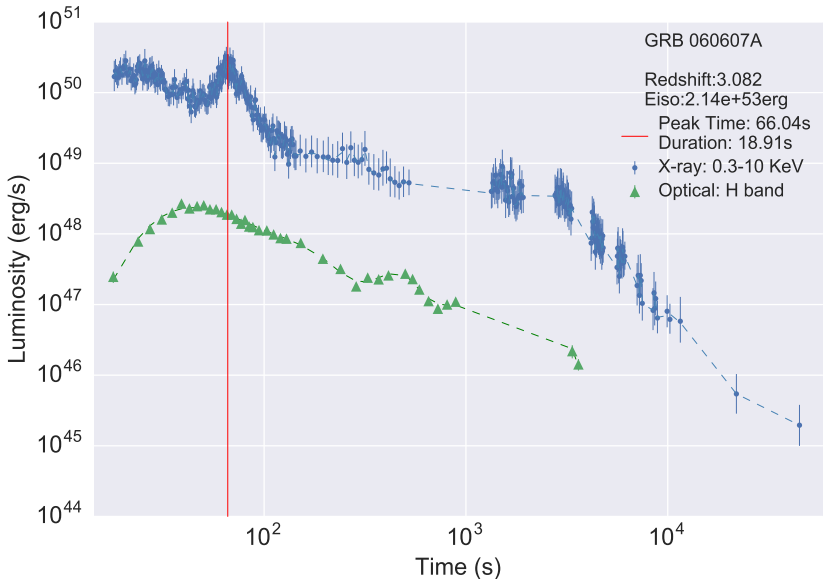



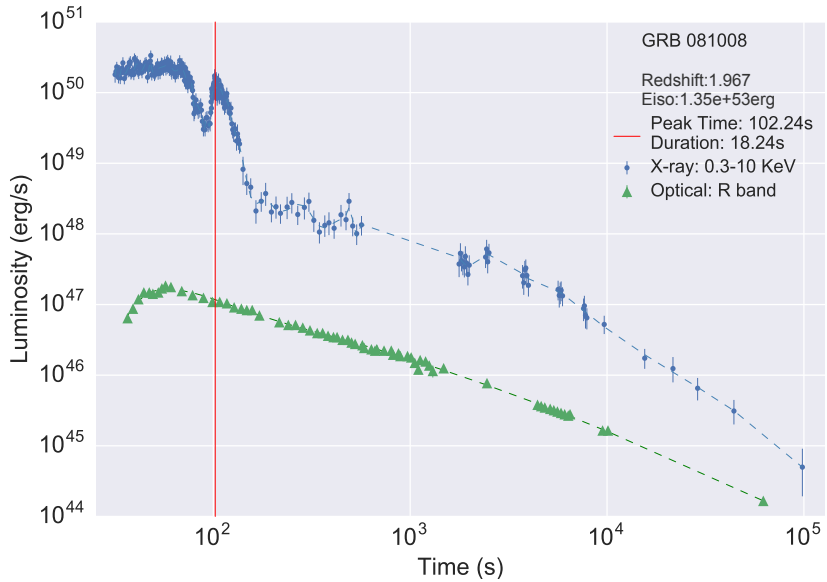

Aimuratov (2020) Ph.D. thesis

# phenomenology of SN association



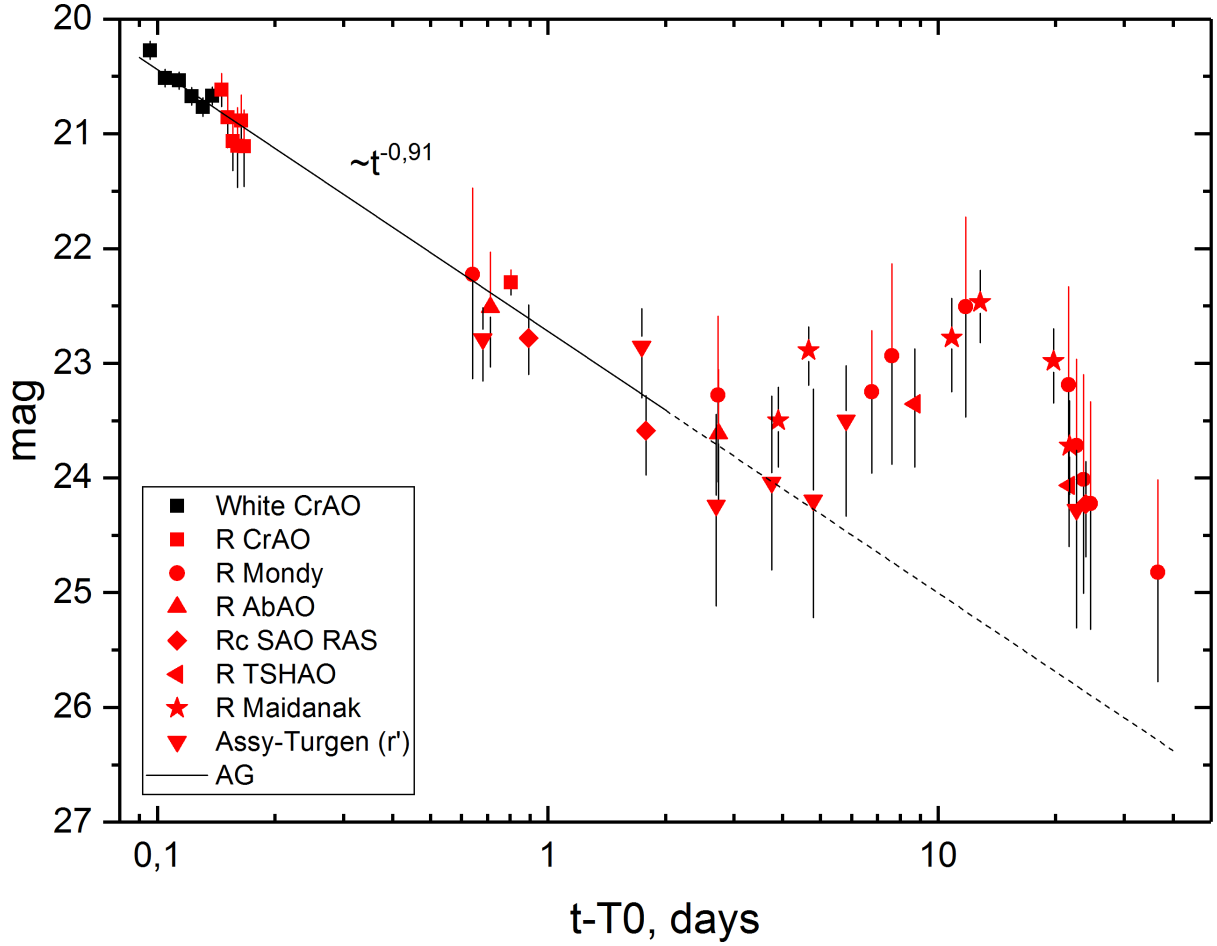



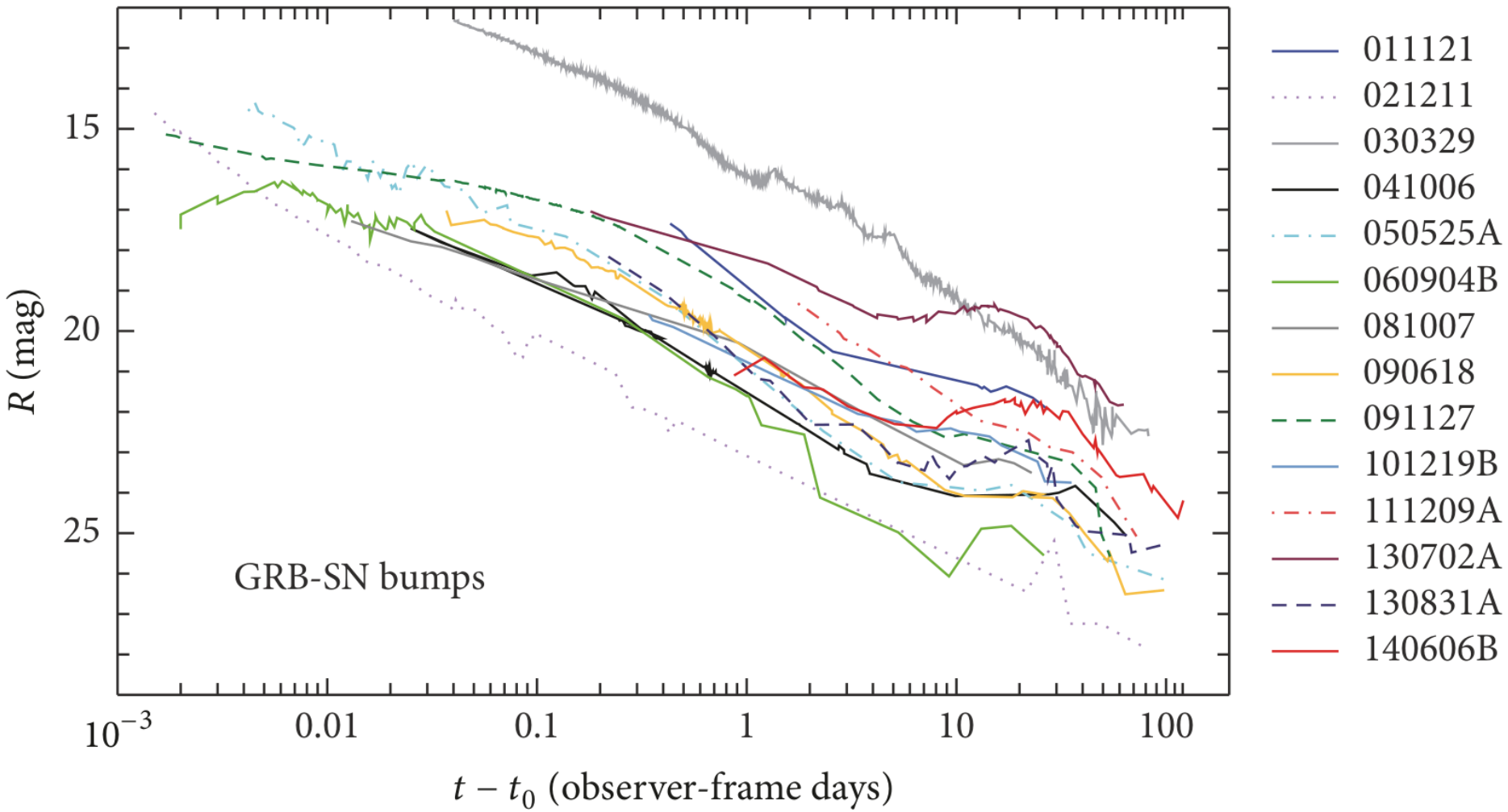




Ruffini et al. (2018) ApJ 852, 53

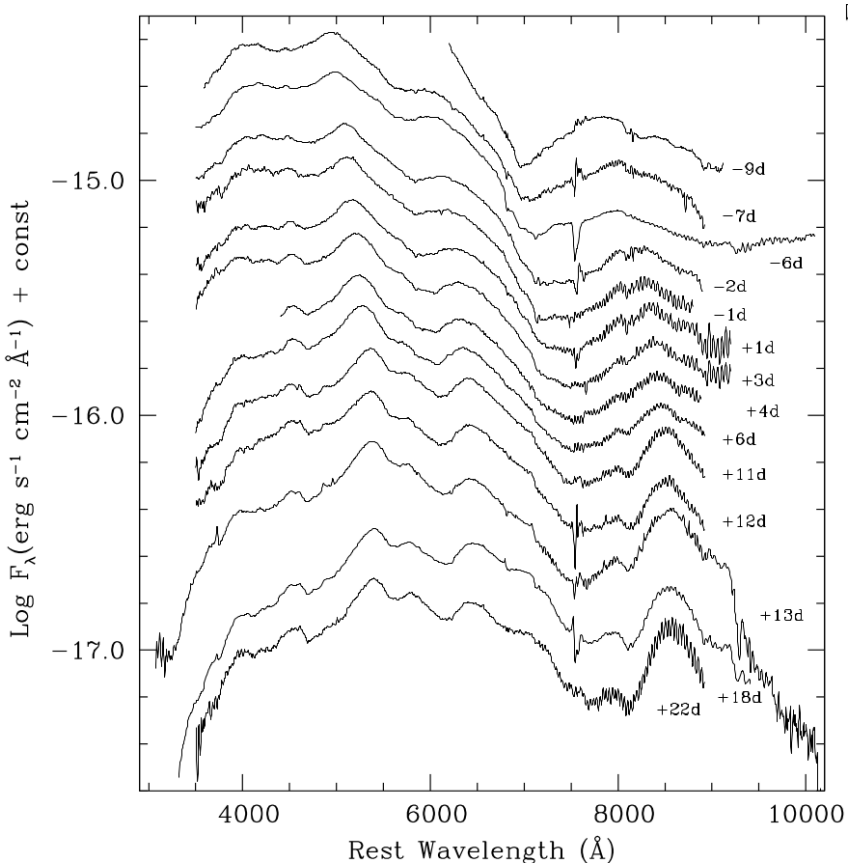
# GRB 201015A optical afterglow light curve

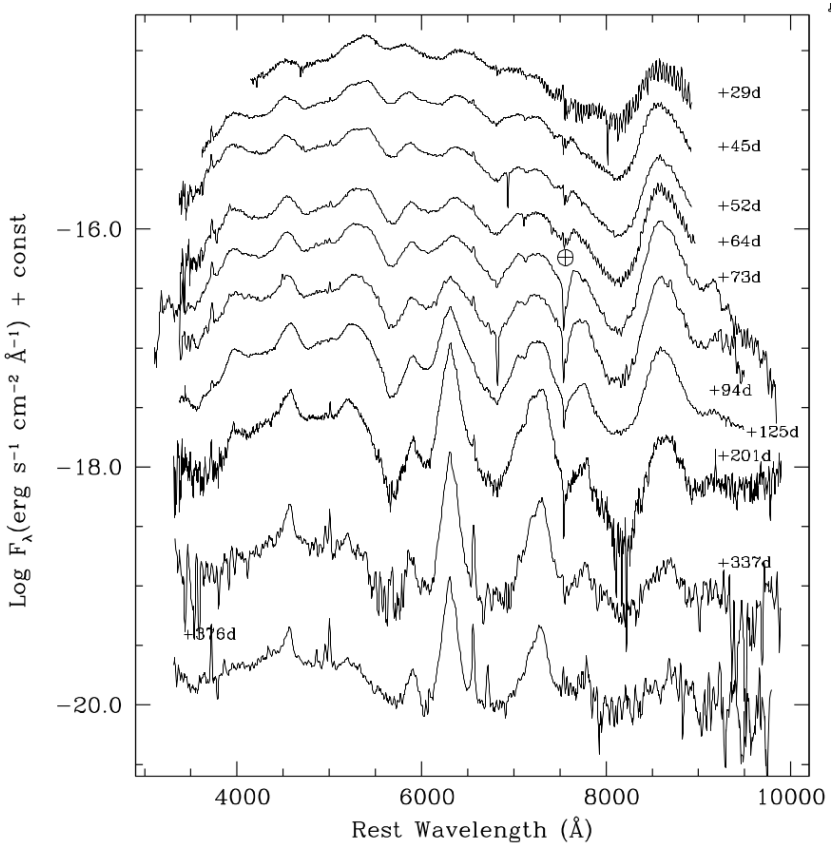



Pozanenko et al. (2020) GCN, id 29033

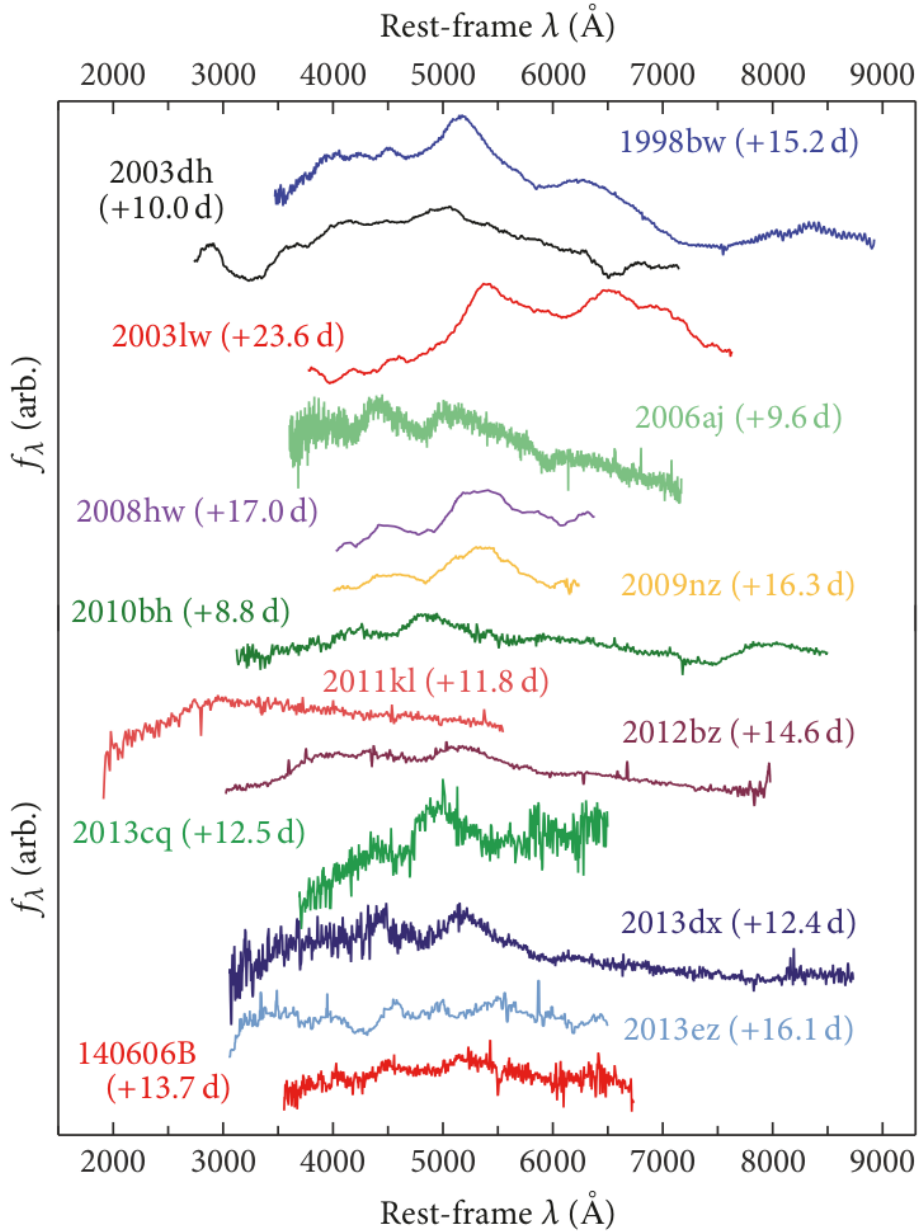



Cano et al. (2017) AdvanAstr, id 8929054

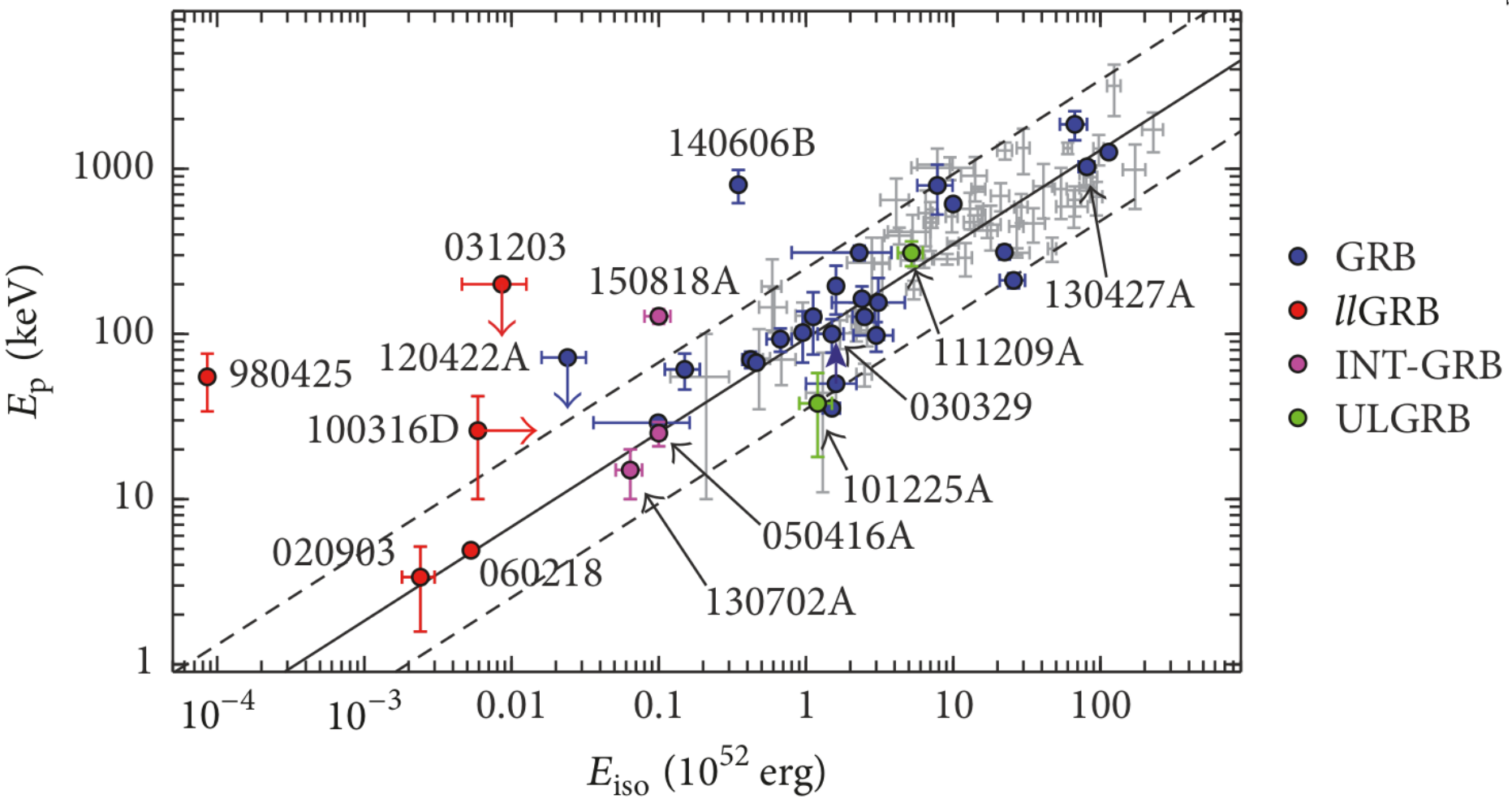


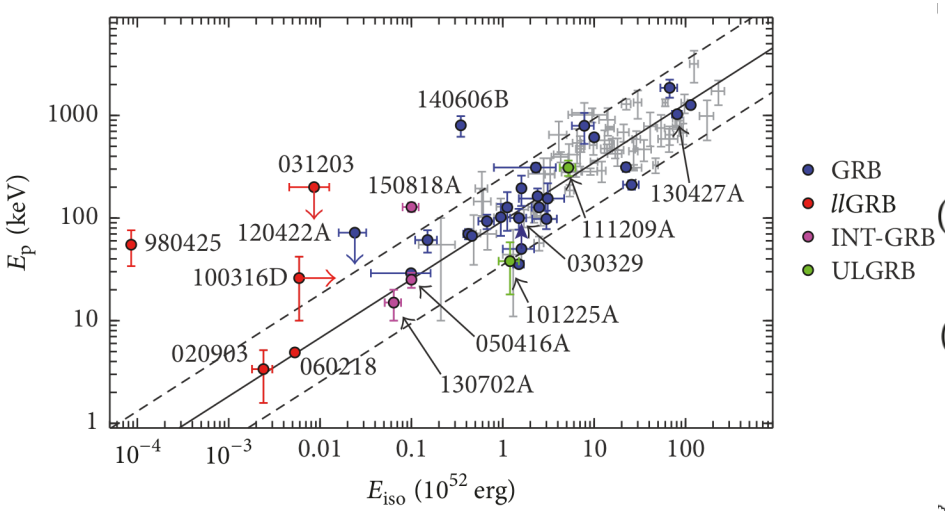

Patat et al. (2001) ApJ 555, 900




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 $\gamma$-ray emission (~$10^4$ seconds [53, 54]) rather than on their $\gamma$-ray luminosities.

Cano et al. (2017) AdvanAstr, id 8929054

a word on GeV-GRB-SN population

You reasonably expect a small sample*

However a deeper study of GRBs both associated with SNe and emitting high-energy GeV photons 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 **very** small sample

Sampling:

| GeV-GRB-SN | = | GeV-GRB | ∩ | GRB-SN |
|---|---|---|---|---|
| ? | | $>$ 200 (yes/no $z$) | | 59 (ph+sp) |

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

# GeV-GRB-SN population

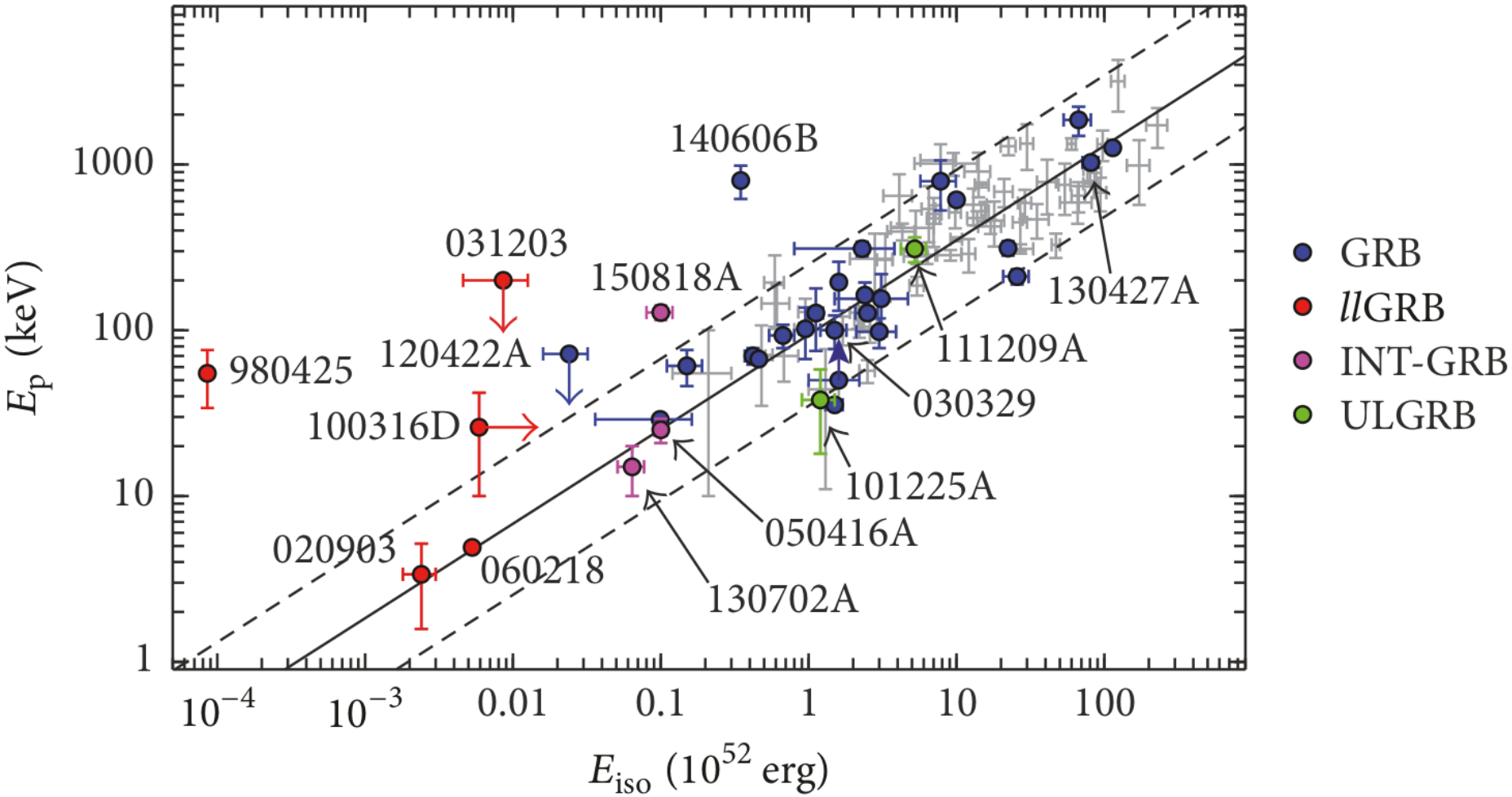
| GRB | GeV | SN | Redshift |
|---|---|---|---|
| 190829A | UL | 2019oyw | 0.0785 |
| 190114C | yes | 2019jrj | 0.4245 |
| 180728A | yes | 2018fip | 0.1170 |
| 171205A | yes | 2017iuk | 0.0368 |
| 130702A | yes | 2013dx | 0.1540 |
| 130427A | yes | 2013cq | 0.3399 |

# +24 candidates to GeV-GRB-SN population

| GRB | GeV | SN | Redshift |
|---|---|---|---|
| 201015A | ... | bump | 0.4260 |
| **200826A*** | no (73°) | AT2020scz | 0.7481 |
| 181201A | yes | bump | 0.4500 |
| 171010A | yes | 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 |
| 111209A | ... | 2011kl | 0.6770 |
| 101225A | ... | bump | 0.8470 |
| 101219B | ... | 2010ma | 0.5519 |
| 100621A | ... | bump | 0.5400 |

- 6 GeV-GRB-SN
- +24 candidates occurred within *Fermi*-LAT era (since mid-2008)
- +29 GRB-SN occurred in pre-*Fermi* era (since 1998)

# What is interesting in GeV-GRB-SN population?




Cano et al. (2017) AdvanAstr, id 8929054

GeV-GRB-SN: compare

Nothing to compare at the first glance
since energetics and spectra/lightcurves
are identical
to the normal GeV-GRB and GRB-SN separately

What is interesting in **candidates** list?

| **GRB** | **GeV** | **SN** | **Redshift** |
|---|---|---|---|
| **200826A**$^*$ | no ($\theta = 73^\circ$) | AT2020scz | 0.7481 |

arXiv.org > astro-ph > arXiv:2105.05067

**Astrophysics > High Energy Astrophysical Phenomena**

*[Submitted on 11 May 2021 (v1), last revised 13 May 2021 (this version, v2)]*

# Discovery and confirmation of the shortest gamma ray burst from a collapsar

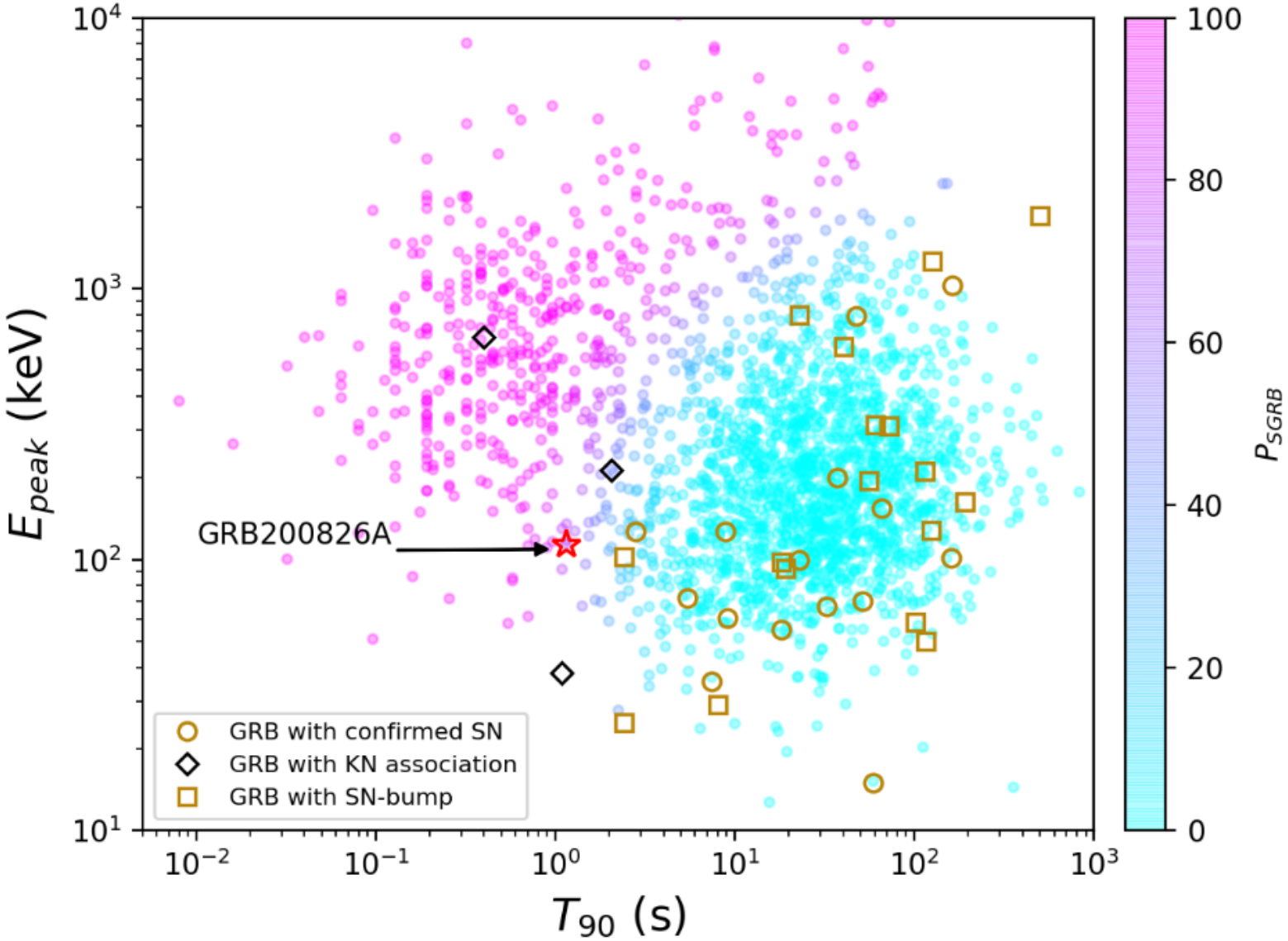
Tomas Ahumada, Leo P. Singer, Shreya Anand, Michael W. Coughlin, Mansi M. Kasliwal, Geoffrey Ryan, Igor Andreoni, S. Br
T. H. Pang, Eric Burns, Virginia Cunningham, Simone Dichiara, Tim Dietrich, Dmitry S. Svinkin, Mouza Almualla, Alberto J. Ca
Gatkine, Erica Hammerstein, Shabnam Iyyani, Joseph Mangan, Dan Perley, Sonalika Purkayastha, Eric Bellm, Varun Bhalera
Poonam Chandra, Dmitry A. Duev, Dmitry Frederiks, Avishay Gal-Yam, Matthew Graham, Anna Y. Q. Ho, Kevin Hurley, Viraj
Mahabal, Frank Masci, Sheila McBreen, Shashi B. Pandey, Simeon Reusch, Anna Ridnaia, Philippe Rosnet, Benjamin Rusho
Soumagnac, Robert Stein, Eleonora Troja, Anastasia Tsvetkova, Richard Walters, Azamat F. Valeev

Gamma-ray bursts (GRBs) are among the brightest and most energetic events in the universe. The duration and hardness distribution of GRBs
different progenitors. Short-hard GRBs (SGRBs; T90 <2 s) arise from compact binary mergers, while long-soft GRBs (LGRBs; T90 >2 s) have be
(collapsars). The discovery of SN 1998bw/GRB 980425 marked the first association of a LGRB with a collapsar and AT 2017gfo/GRB 170817A/
binary neutron star merger, producing also gravitational wave (GW). Here, we present the discovery of ZTF20abwysqy (AT2020scz), a fast-fadin
InterPlanetary Network (IPN) localization regions of GRB 200826A; X-ray and radio emission further confirm that this is the afterglow. Follow-up
above the afterglow that cannot be explained as an underlying kilonova (KN), but is consistent with being the supernova (SN). Despite the GRB
panchromatic follow-up data confirms a collapsar origin. GRB 200826A is the shortest LGRB found with an associated collapsar; it appears to si
Our discovery is consistent with the hypothesis that most collapsars fail to produce ultra-relativistic jets.

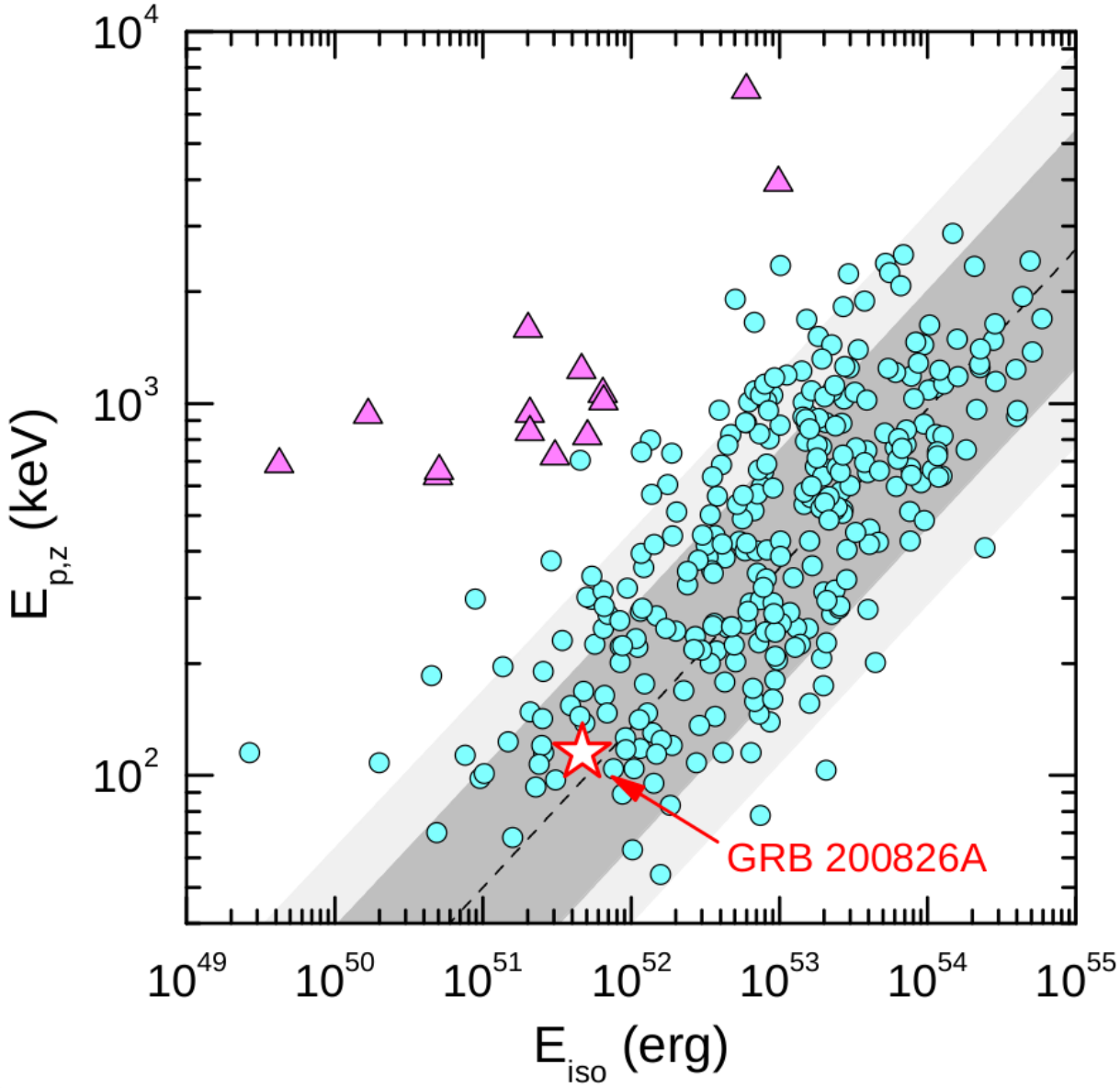
Comments: submitted to Nature Astronomy
Subjects: **High Energy Astrophysical Phenomena (astro-ph.HE)**
Cite as: arXiv:2105.05067 **[astro-ph.HE]**
(or arXiv:2105.05067v2 **[astro-ph.HE]** for this version)

Ahumada et al. (2021) arXiv: 2105.05067

# GRB 200826A: $T_{90} = 0.65$ seconds only (!)




Ahumada et al. (2021) arXiv: 2105.05067




Ahumada et al. (2021) arXiv: 2105.05067

GeV-GRB-SN: summary

Does GeV-GRB-SN population worth to be told on MG16 meeting?
Yes

Are the results enough to attract your attention?
May be not enough
But we are still working on them

Thank you for attention!

# Questions?

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