A Catalogue of GRBs and their Precursors

https://icecube.wisc.edu/~grbweb_public/

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1. Introduction

Gamma-Ray Bursts (GRBs) are the most energetic transient sources of electromagnetic radiation in our universe. They can occur when super-massive stars undergo core collapse, leading to a long burst ($T_{90} > 2$ s), or after the coalescence of a binary neutron star system, leading to a short burst ($T_{90} < 2$ s). The accretion of matter on the newly formed compact object will lead to the ejection of shells of matter along a relativistic jet. GRBs are hence expected to be a source of (ultra-high-energy) cosmic-rays and astrophysical neutrinos. To enable multi-messenger GRB studies, we have constructed a catalogue of GRBs and GRB precursors.

2. GRBweb

An all-inclusive GRB catalogue:
Built on Python, MySQL, and HTML5, GRBweb is an online tool that combines data from the

- Fermi-GBM & LAT [1, 2]
- Swift-BAT, XRT & UVOT [3]
- IPN-network [4]

catalogues with follow-up observations reported via the GCN-network [5] into a single, easy-to-use GRB database.

Content:

- >7000 GRBs
  → Information grouped per burst
- Sub-threshold GRB triggers
- Precursor catalogues

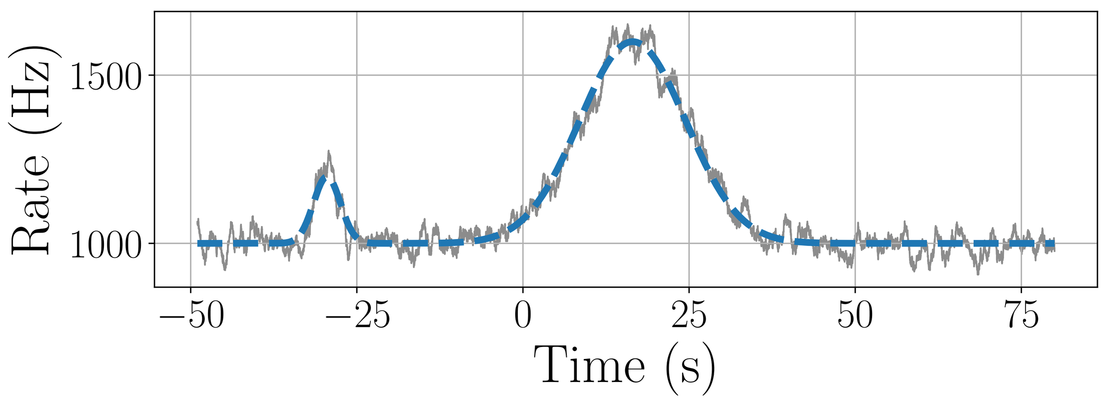
In addition, GRBweb contains meta-data related to its construction and supplementary information on how the data can be easily accessed.

Updated on a weekly basis

3. Precursors

What are they?

- Flashes of gamma radiation that precede the main outburst by ∼ tens of seconds
- Dimmer than the prompt emission
- Typically follow a non-thermal spectrum
- Observed in ∼10% of all GRBs



Why are they interesting?
During the initial stages of GRBs, the denser environment could lead to more hadronic interactions, resulting in an increased neutrino flux.

4. Fermi-GBM Precursor Search

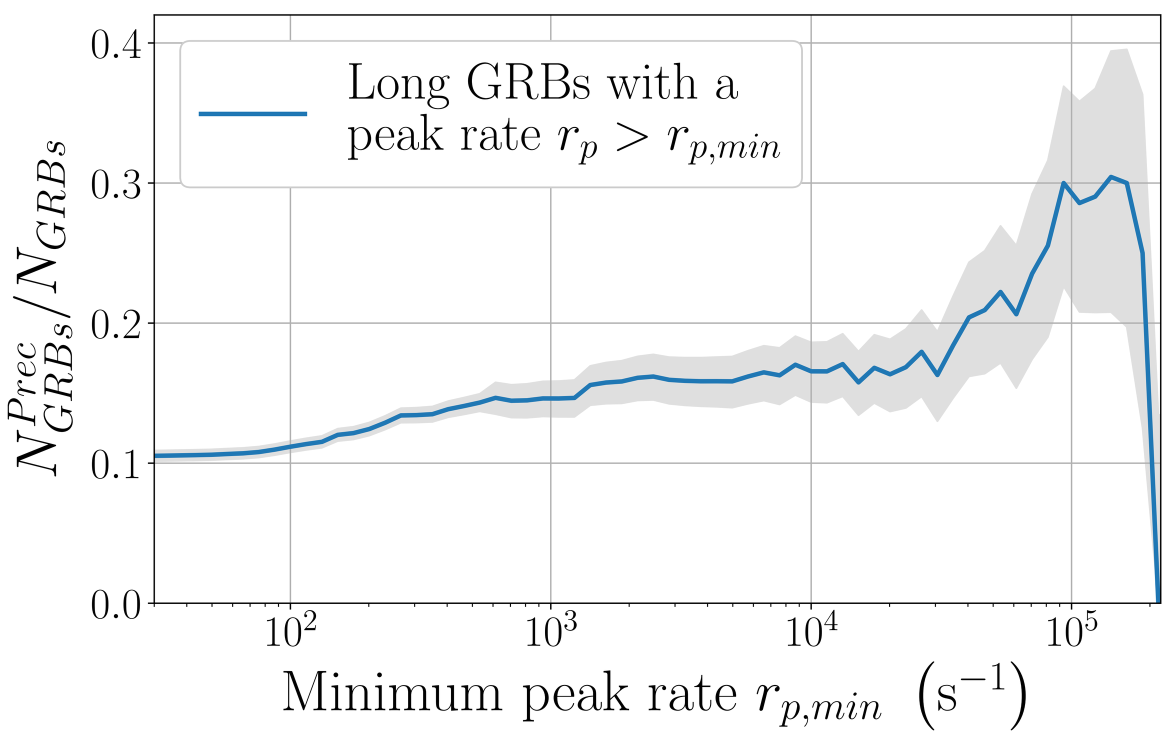
Data:

- 2364 GRBs
- ±1000 s time window around trigger
- 8 keV to 1 MeV energy range
- Available from HEASARC [6]

Method:

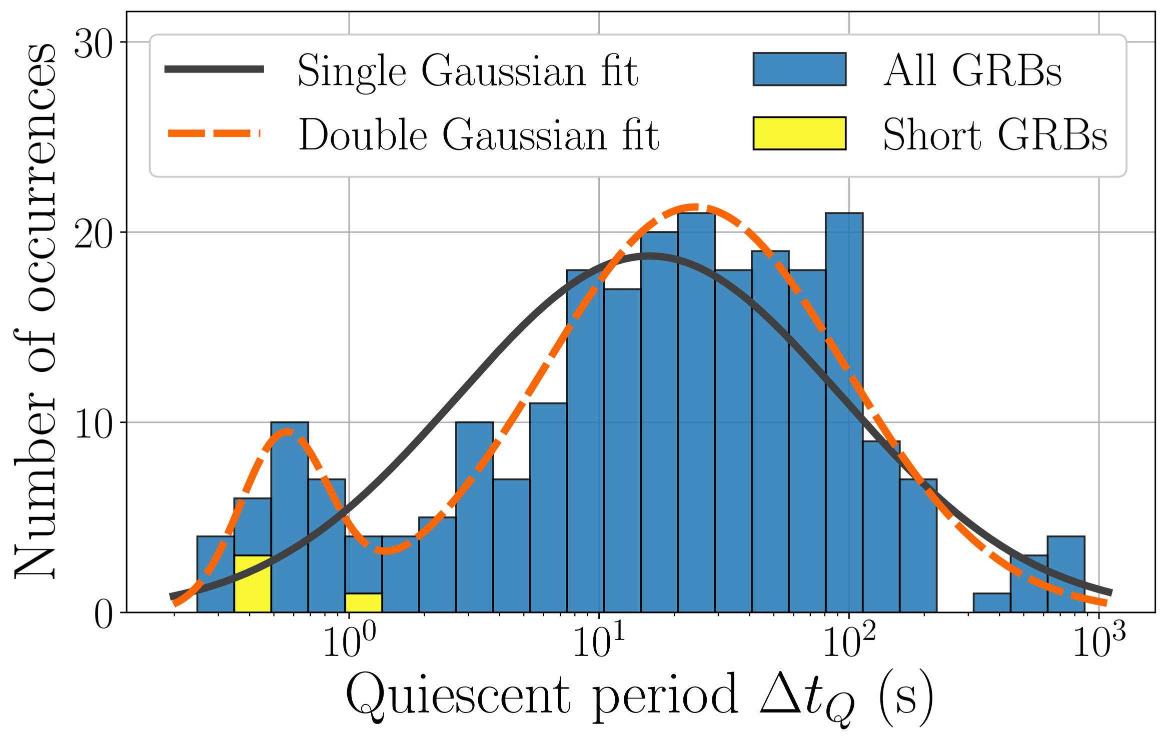
- Bayesian block binning
- Apply background subtraction
- Require signal in ≥ 2 sub-detectors

5. Precursor Analysis Results



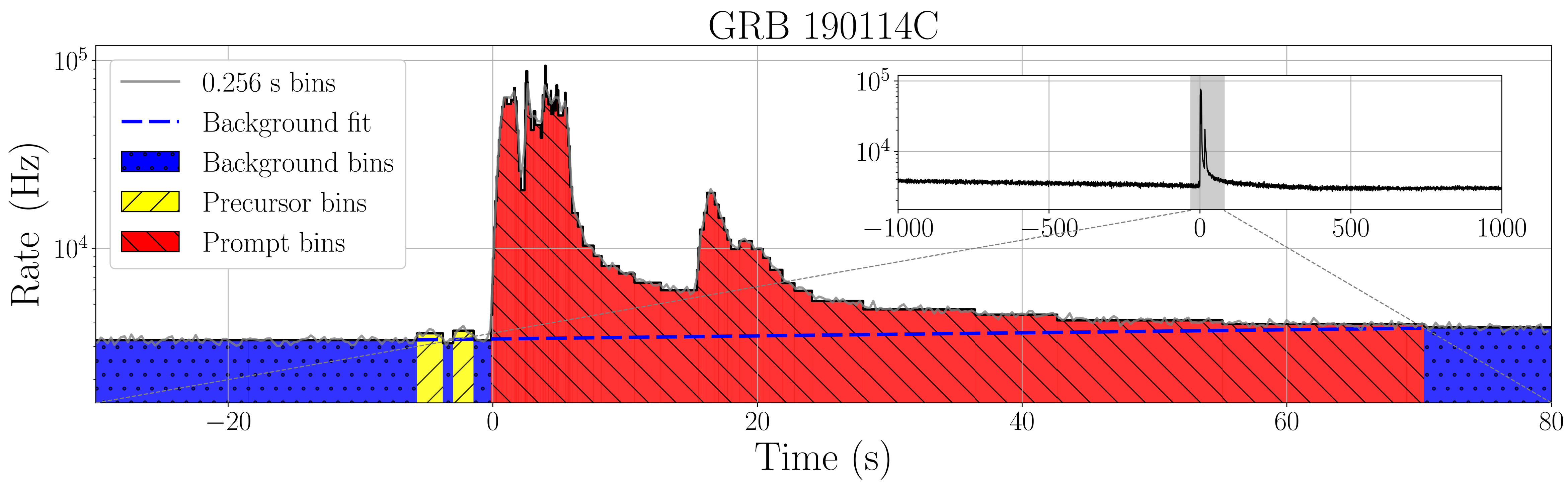
Number of precursors:

- 244 precursors observed
  → 10% for long GRBs
  → ∼1% for short GRBs
- When including only sufficiently bright long bursts, 16% has a precursor (left figure)
- GRB 190114C, the first GRB from which TeV gamma-ray were detected, was preceded by two short precursors (bottom figure)



Quiescent times:
Precursors to short GRBs occur within 2 s of the prompt emission.
Over the full distribution (left figure), we observe a bi-modal feature. A double Gaussian fit ($p = 0.36$) is strongly preferred over a single Gaussian fit ($p = 8 \times 10^{-5}$). This indicates that the precursors could result from different physical progenitors.

Full results recently published in PRD [7].
Precursor selection available on GRBweb.



6. Conclusions

GRBweb

GRBweb is a publicly available online catalogue that contains data on over 7000 GRBs from a wide range of detectors, along with meta-data and tools to extract the data.

Precursor Analysis

We analysed the light curves of 2364 bursts, identified 217 bursts with precursors emission, and found that the distribution of their quiescent times displays a bi-modal feature.

7. References

[1] A. von Kienlin et al. The fourth Fermi-GBM gamma-ray burst catalog: A decade of data. *The Astrophysical Journal*, 893(1):46, Apr 2020.

[2] M. Ajello et al. A decade of gamma-ray bursts observed by Fermi-LAT: The second GRB catalog. *The Astrophysical Journal*, 878(1):52, Jun 2019.

[3] Amy Lien et al. The third Swift burst alert telescope gamma-ray burst catalog. *The Astrophysical Journal*, 829(1):7, Sep 2016.

[4] K. Hurley et al. The interplanetary network supplement to the Fermi-GBM catalog of cosmic gamma-ray bursts. *The Astrophysical Journal Supplement Series*, 207(2):39, Aug 2013.

[5] S. D. Barthelmy et al. GRB Coordinates Network (GCN): A status report. In *Gamma-ray Bursts, 5th Huntsville Symposium*, volume 526, pages 731–735, Sep 2000.

[6] `https://heasarc.gsfc.nasa.gov/FTP/fermi/data/gbm/bursts`.

[7] P. Coppin et al. Identification of gamma-ray burst precursors in Fermi-GBM bursts. *Phys. Rev. D*, 102:103014, Nov 2020.