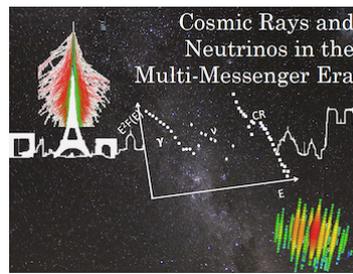


# Cosmic Rays and Neutrinos in the Multi-Messenger Era



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## A Catalogue of GRBs and their Precursors

Gamma-Ray Bursts (GRBs) have historically been regarded as one of the prime potential sources of (ultra-high-energy) cosmic rays and astrophysical neutrinos. They can occur following the collapse of a super-massive star or the coalescence of a binary neutron star system. In both cases, a compact object is formed, from which a highly-relativistic jet is subsequently expelled. In terms of their emitted electromagnetic power, GRBs are unrivalled by any other class of cosmic transients. If hadronic acceleration takes place in GRB jets, a signal could potentially be observed by current neutrino telescopes, such as the IceCube detector.

### GRBweb

To enable studies looking for multi-messenger counterparts, we have composed a comprehensive catalogue of GRBs, called GRBweb. This catalogue pools observations by dedicated missions, such as Fermi and Swift, with observations from gamma-ray satellites in the IPN network and follow-up studies reported via GCN circulars. After unifying the data format, a summary table is composed, grouping all available data per GRB. GRBweb is updated on a weekly basis and publicly available at [https://icecube.wisc.edu/~grbweb\\_public](https://icecube.wisc.edu/~grbweb_public). To ensure user friendliness, the web interface also provides examples on how to load the data and information on the data format and resources that were used.

### Precursors

While this catalogue houses all information on GRB prompt emission, another phase of particular interest is that of the precursor flashes that precede  $\sim 10\%$  of all GRBs. During the precursor stage, the large density at early times could enhance hadronic interactions with respect to the prompt phase. As a result, GRB neutrinos could predominantly come from the precursor stage. To allow such correlation studies, we composed a precursor catalogue by analysing 11 years of Fermi-GBM data. A Bayesian block algorithm was used to identify statistically significant excesses of gamma radiation before the onset of the prompt emission. A total of 217 GRBs with precursor emission were identified out of 2364 bursts. The temporal properties and light curves of these events can be accessed via GRBweb.

### Follow-up studies

In this poster, we present a first application of the presented GRB (precursor) catalogue. By analysing the statistical properties of the precursor sample, we uncovered a novel feature in their temporal characteristics, potentially indicating the existence of two progenitor source classes. Follow-up studies to further investigate this bimodality are encouraged.

## Related session

Multi-messenger

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