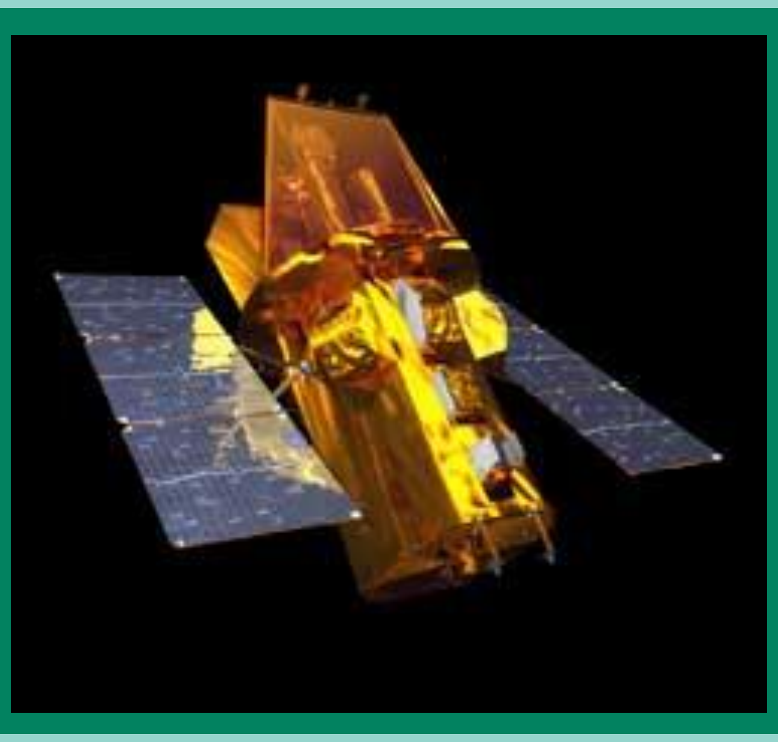

Constraints on fast radio burst emission in the aftermath of *Swift* detected GRBs

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Scan Me :)

Abstract

Fast radio bursts (FRBs) are highly energetic radio transients lasting milliseconds with unknown physical origins. Magnetars are considered possible FRB sources, supported by observations of the galactic magnetar SGR 1935+2154. Since magnetars may also power some gamma-ray bursts (GRBs), these phenomena might share common progenitors. We investigated this hypothesis by cross-matching *Swift* GRBs with well-localized FRBs from the FRBSTATS catalogue, applying both spatial and temporal constraints. While recovering two previously reported low-significance associations, our analysis shows that current observational data cannot conclusively exclude or confirm physical connections between GRBs and FRBs. Next-generation GRB and FRB detectors will be crucial for placing more stringent constraints on this hypothesis.

Introduction

The enigmatic FRBs have puzzled astronomers since their discovery. The detection of a radio burst from galactic magnetar SGR 1935+2154 (as shown in Fig. 1) established the first direct link between magnetars and FRBs. Magnetars have also been proposed as power sources for GRBs, with models successfully explaining X-ray emission properties. Multiple theoretical scenarios suggest possible GRB-FRB connections with varying time delays. The lack of confirmed associations could be attributed to instrumental sensitivity limitations or differing emission beaming angles rather than the absence of physical connections.

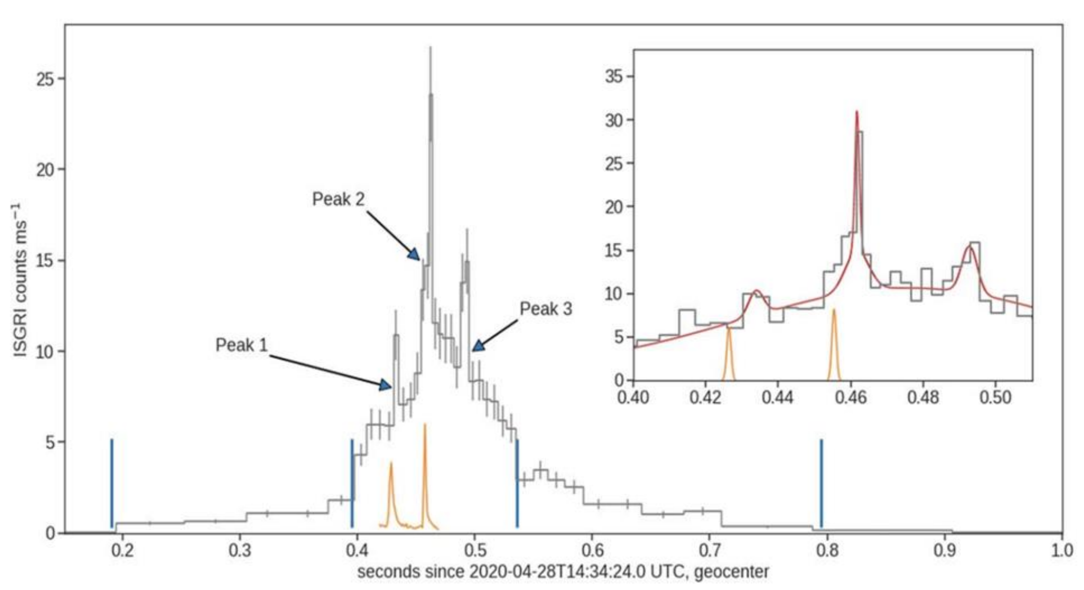

Fig.1 (from Mereghetti et al., 2020.): INTEGRAL burst (grey lightcurve) detected in association with radio emission from the magnetar SGR 1935+2154 (yellow lightcurve).

Methodology & Results

Our approach involved:

1. Selecting all *Swift* GRBs with precise XRT localizations, including long and short events (1276 events,, with 400 having a redshift measurement), as well as 32 well-localized pre-*Swift* GRBs with known redshifts
2. Taking into account all FRBs from FRBSTATS with localization accuracy ≤30′ (633/828 events)
3. Applying spatial coincidence criteria (distance <3σ) between FRBs and the two collection of GRBs
4. Requiring FRBs to follow GRBs temporally, leading us to a sample of 21 possible associations, all with non-repeating FRBs (Fig. 2)
5. For known-redshift GRBs, requiring GRB redshift < FRB redshift

We found only two, low-significance associations following our selection criteria:

A. **GRB 110715A**, a long GRB at z=0.82, and **FRB 20171209A**, a non repeating FRB discovered by Parkes with an inferred distance of z = 1.17

B. **GRB 060502B**, a short GRB at an estimated redshift z =0.287, and **FRB 20190309A** , a non repeating FRB discovered by CHIME with an inferred distance of z= 0.32.

Simulating 1276 GRBs and 516 out of 633 FRBs, detected by CHIME (in order to take into account a homogeneous sample), and requiring constraints 1-5, we found that the mean value of **number of matches is 1.6** (with σ=0.9)

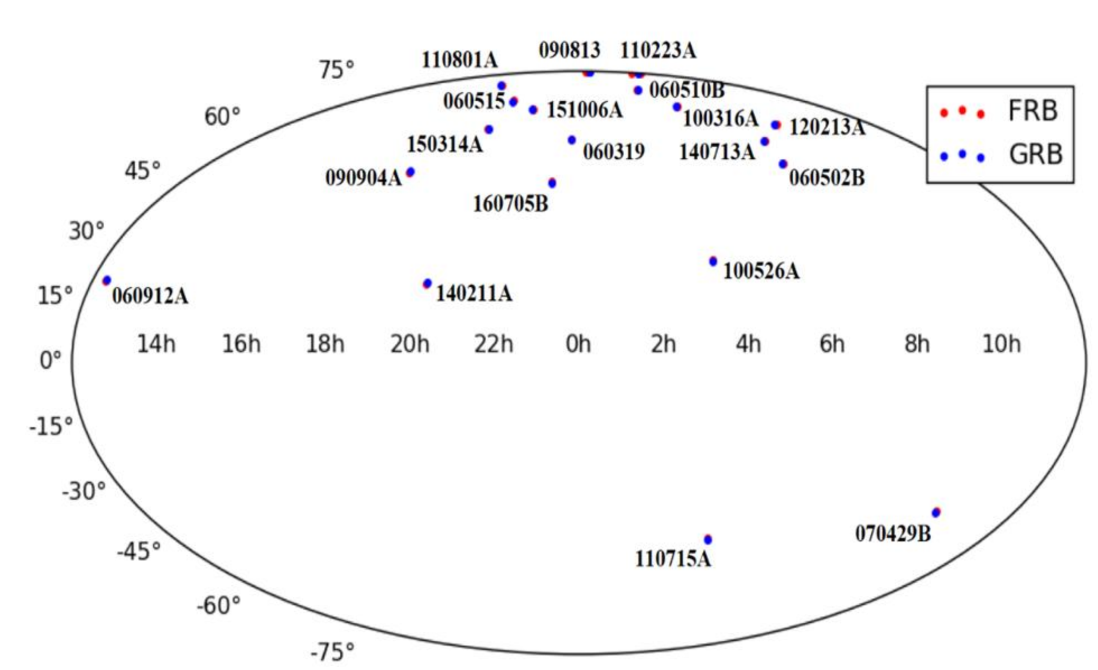

Fig. 2: FRBs and GRBs with a positive match. The GRB names are also shown.

Can we rule out the association between gamma-ray bursts and fast radio bursts?

To answer this question, since no clear association between GRBs and FRBs has been found, we explored the probability of detecting an FRB from a GRB assuming that all GRBs produce an FRB. We focused on non-repeating FRBs, as they are more likely linked to cataclysmic events like GRBs.

We generated a synthetic population of one million FRBs, assigning each a redshift and an isotropic rest-frame energy. The redshift distribution was based on *Swift* detected bursts. The rest-frame isotropic energy was drawn from the FRB energy distribution modelled as Schechter function following Hashimoto et al. (2022), accounting for two different redshift bins.

To estimate the detection rate, we computed the observed fluence of these FRBs in the CHIME band and compared it with the CHIME sensitivity threshold. Only one to two percent of the simulated FRBs had fluences above this limit. Considering the Swift GRB detection rate, we estimated an FRB detection rate of [5-11] x 10^-3 per year for CHIME (Fig. 3A).

Repeating the analysis for Parkes and ASKAP, we found lower detection rates, with [1-2] x 10^-5 per year for Parkes and [4-8] x 10^-4 per year for ASKAP (Fig. 3B).

Our results suggest that the lack of observed FRB-GRB associations does not rule out a connection, as expected detection rates are low. Including repeating FRBs in future analyses may increase the predicted rates.

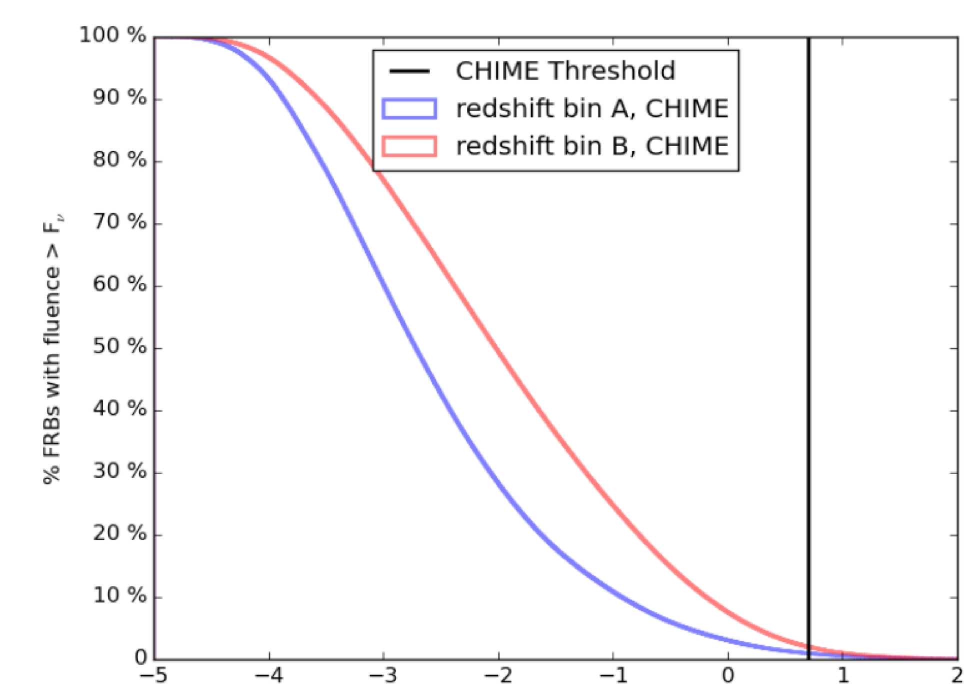

Fig. 3A: Percentage of simulated FRBs with a fluence greater than or equal to Fν, compared to CHIME threshold.

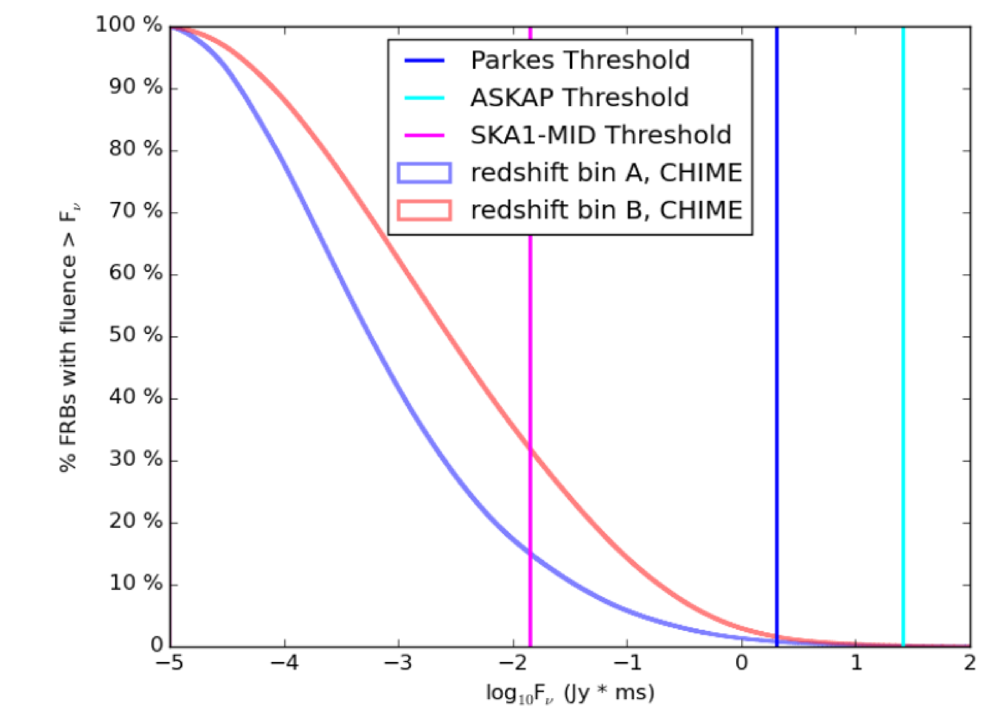

Fig. 3A: Percentage of simulated FRBs with a fluence greater than or equal to Fν, compared to Parkes, ASKAP, and SKA1 MID threshold.

Taking into account future facilities such as SKA1-MID, expected to be operational in the late 2020s, we computed a detection rate of [1-3] × 10^{-3} (Fig. 3B). Despite its much higher sensitivity, the smaller field of view limits the number of detectable events.

However, thanks to its higher sensitivity, SKA will probe the faint end of the FRB energy distribution and might discover new features that are not accounted for in our model.

Conclusion

- The absence of unambiguous GRB-FRB associations does not exclude common progenitors.
- Current detection capabilities would require hundreds of observation years to identify even one associated pair. Future instruments like SKA1-MID will offer improved, though still limited, detection prospects.
- On the GRB side, the THESEUS mission (launching 2037) will detect ~10 times more GRBs than *Swift*, potentially enabling joint detection within a ~10-year timeframe.
- Our results apply to any time delay between GRBs and FRBs up to several decades, providing important constraints for theoretical models while highlighting the need for next-generation instruments to resolve this question definitively.