Bursts from Rotation Powered Magnetars
Swift J1818.0–1607 and PSR J1846.4–0258

Özge Keskin, Yuki Kaneko, Ersin Göğüş, Oliver J. Roberts, Lin Lin, Matthew G. Baring, Can Güngör, Chryssa Kouveliotou, Alexander J. van der Horst, George Younes

Mete Uzuner

meteuzuner@sabanciuniv.edu

Introduction

Magnetars are isolated, young neutron stars with extreme magnetic field strength and highly energetic repeated emission of short duration. Detection of magnetar-like bursts from two rotational powered radio pulsars [1,2] strengthened the association of RPPs with magnetars. An important question that remains is whether magnetar-like bursts in RPP-like radio beams share common characteristics with bursts from magnetars.

Here, we present our comprehensive study of hard X-ray bursts from Swift J1818 and PSR J1846 detected with Fermi/GBM during their burst active episodes in 2020–21.

Burst Search Methods

We used 8 ms binned Fermi/GBM CTTE data over 10-100 keV energy range. We searched for a significant increase in the count rates of at least two NaI detectors with Bayesian statistics, Poisson statistics, and signal-to-noise ratio.

We filtered out the events if they are caused by Fermi's passage through the South Atlantic Anomaly region or if they were classified as non-SGR source before.

We subjected the remaining candidate events to an identification algorithm that estimates the event direction and calculates likelihood for an event type for each event, and kept the events classified as SGR bursts.

Localization

In order to determine the source of an event, one needs to determine the burst location; however, GBM does not have a precise localization capability.

We estimated the event locations roughly via searching for positive correlation between the peak count rates and detector-to-source angles of all 12 NaI detectors at the burst time. The correlation was determined with linear fits, using all unblocked detectors with $\theta \lesssim 60°$, where θ is the angle between the detectors' zenith to sources at the burst time.

We identified total of 37 and 58 SGR bursts likely originating from Swift J1818 & PSR J1846, respectively.
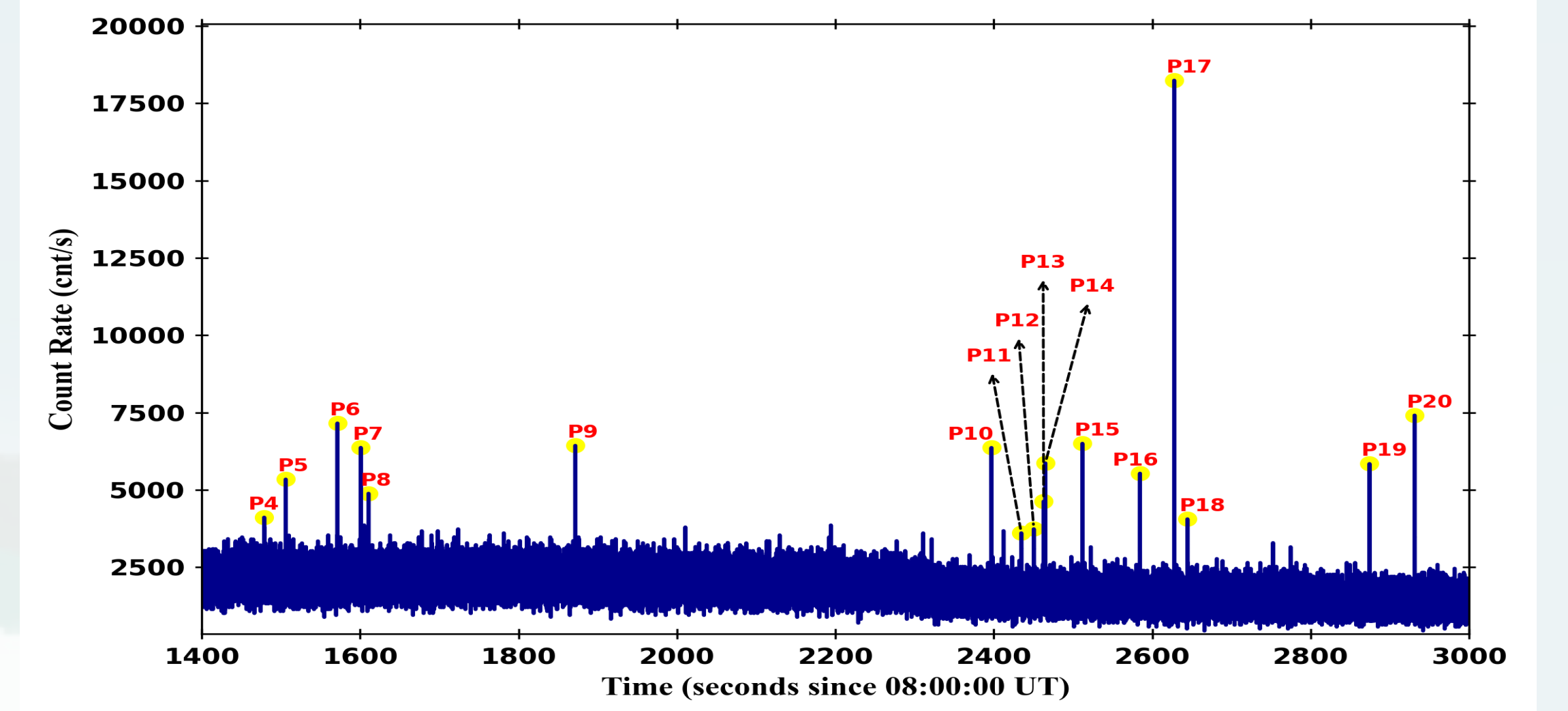

Fig1: GBM lightcurve (10–100 keV, 16 ms binned) for the 8th hour of 2020 July 18, on which multiple bursts are observed, likely coming from PSR J1846.
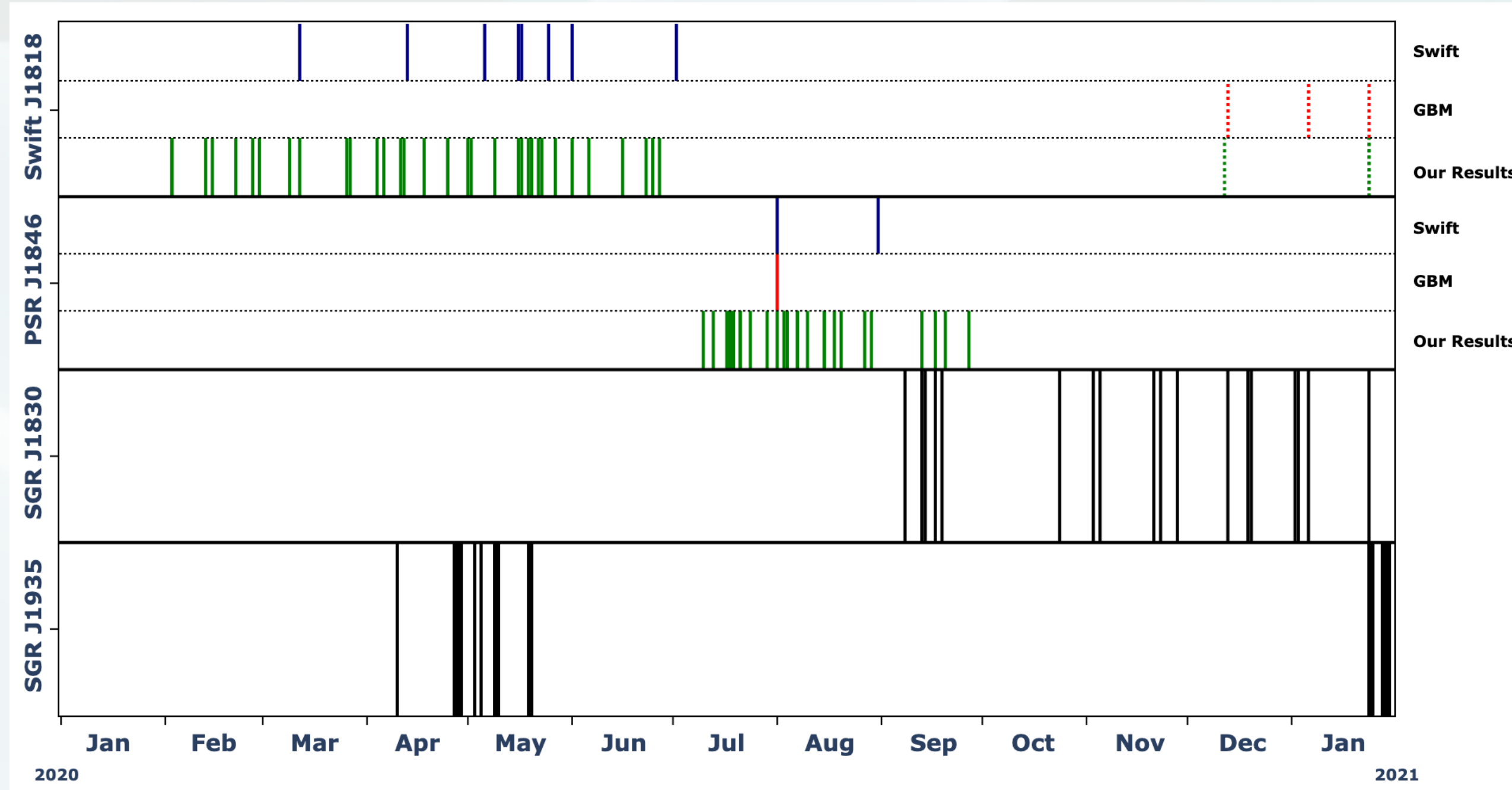

Fig2: Burst timeline of Swift J1818 and PSR J1846 along with two nearby SGR sources that were active in 2020 and January 2021, showing the days on which bursts were detected from each source.

Green lines represent untriggered events identified in this work. The bursts from SGRs J1935+2154 [3] and J1830−0605 (Lin et al. in preparation, Roberts et al. in preparation) are shown in black lines. Events detected with Swift-BAT and Fermi-GBM are indicated with blue and red colors, respectively. Dotted lines in 2020 December to January represent bursts from either Swift J1818.0−1607 or SGR J1830−0605 (the exact origin cannot be identified).

We also note that a single burst from SGR 1806−20, was detected on 2020 April 30 by both Swift-BAT and Fermi-GBM [4,5].

References: [6,7,8,9]

Spectral Analysis

We performed time-integrated spectral analysis of each of these bursts with RMFIT (version 4.3.2) using Castor statistics (C-stat). We generated Detector Response Matrices with GBM Response Generator.

For the analysis, we used 8 ms binned CTTE data of all unblocked detectors with $\theta<60°$, covering the entire duration of the event, and the energy range of 8–200 keV.

We fit each spectrum with three spectral models: Comptonized model, single black body, and sum of two black bodies.
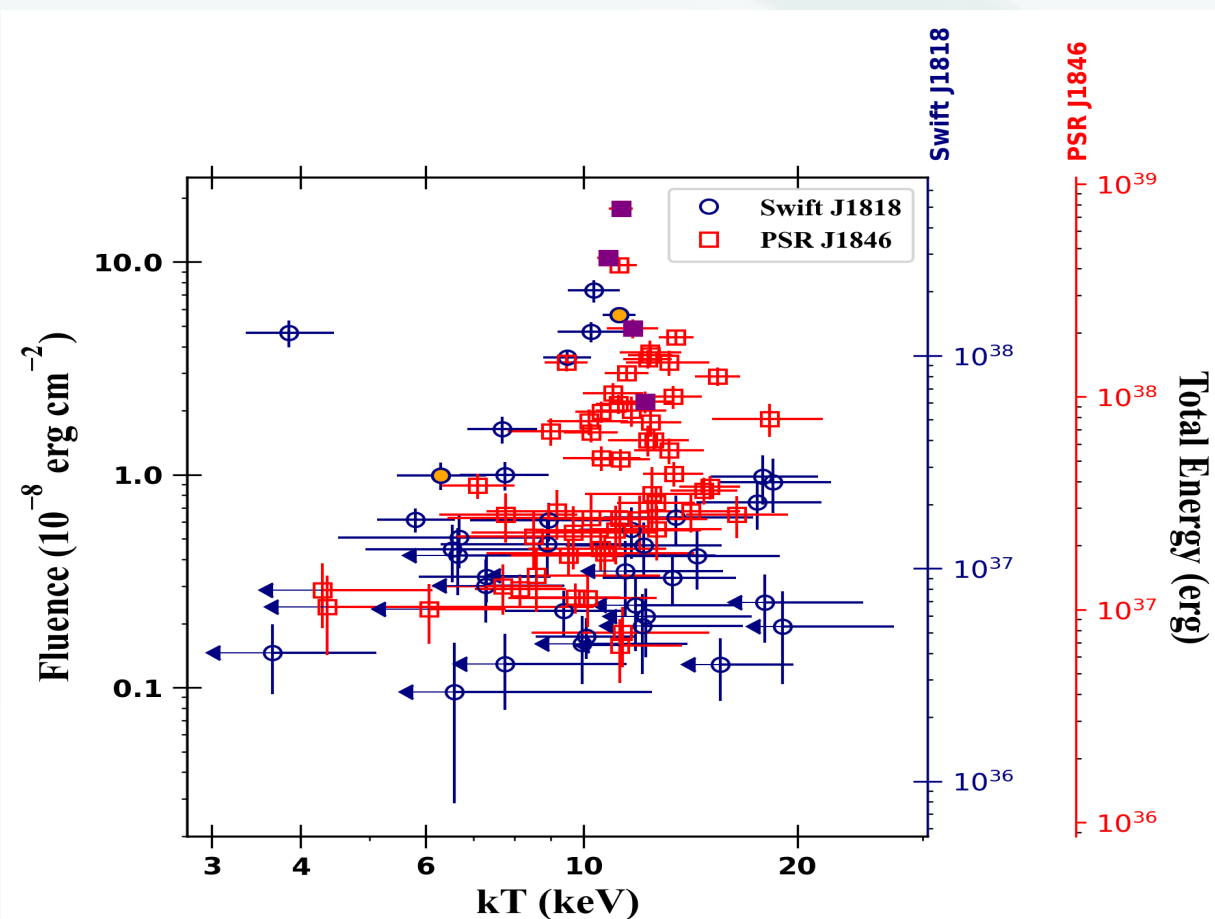

Fig3: All events from both Swift J1818 and PSR J1846 are adequately described with a single BB function.
The BB temperature on average is slightly lower for Swift J1818 (weighted averages of 7.95±0.24 vs. 11.14±0.15 keV).
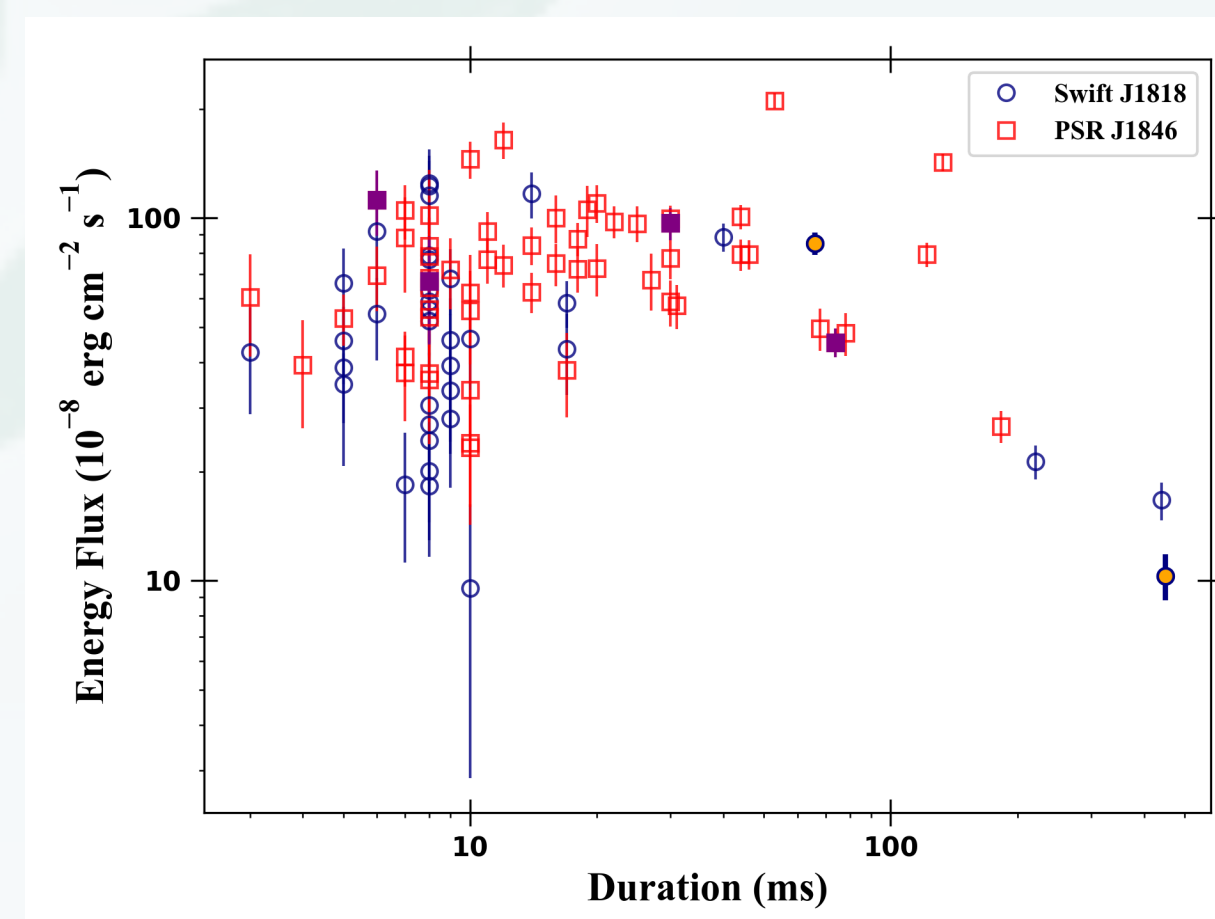We also find no spectral evolution in bursts as seen in other magnetars [3,10].

Fig4: No correlation between burst energy flux and duration. Mean duration of PSR J1846 and Swift J1818 are comparable (25.7 vs. 41.9 ms); however, noticeably shorter than other magnetars.
Average flux of PSR J1846 is slightly higher than Swift J1818 (7.5×10^{-7} vs. 5.4×10^{-7} erg cm^{-2} s^{-1}).
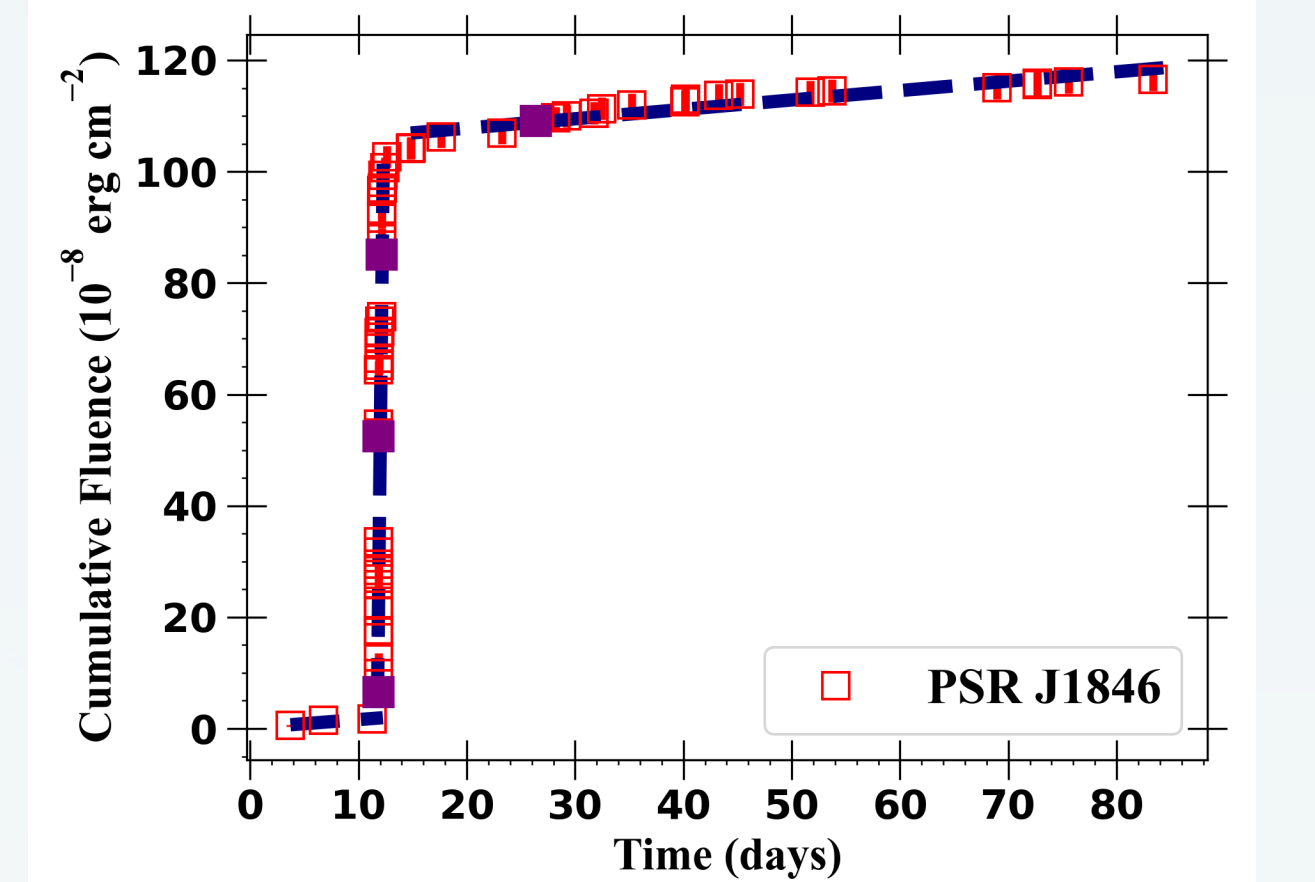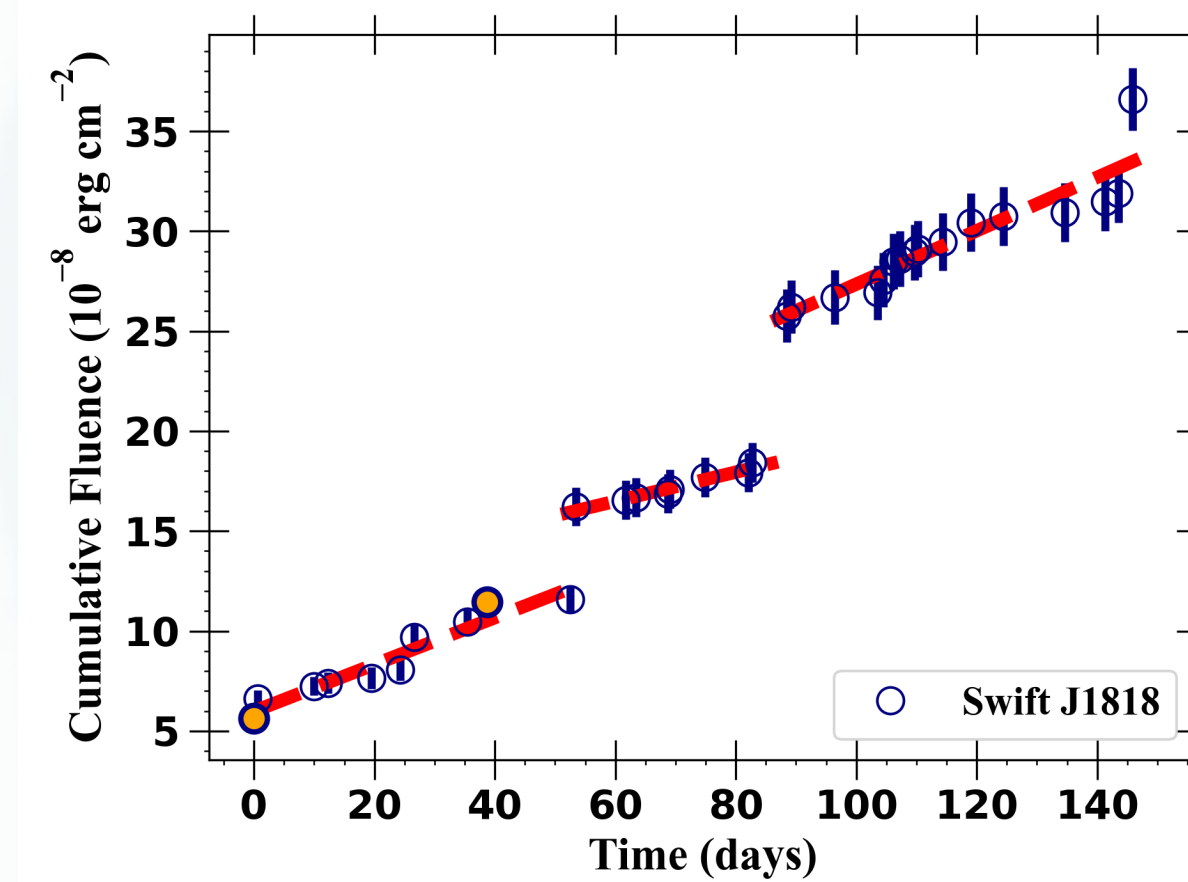
Discussion

Fig5: Time evolution of cumulative burst fluences. Swift J1818 exhibited an overall linear trend in cumulative fluence throughout its burst-active episode. PSR J1846, on the other hand, has characteristically different cumulative burst fluence behavior. The burst-active phase starts on 2020 July 6 and yielding a linear trend comparable to that of Swift J1818 in cumulative burst fluence. Then, on July 18, the source exhibits its most active behavior, emitting 32 bursts, therefore, showing a very rapid rise in cumulative fluence.
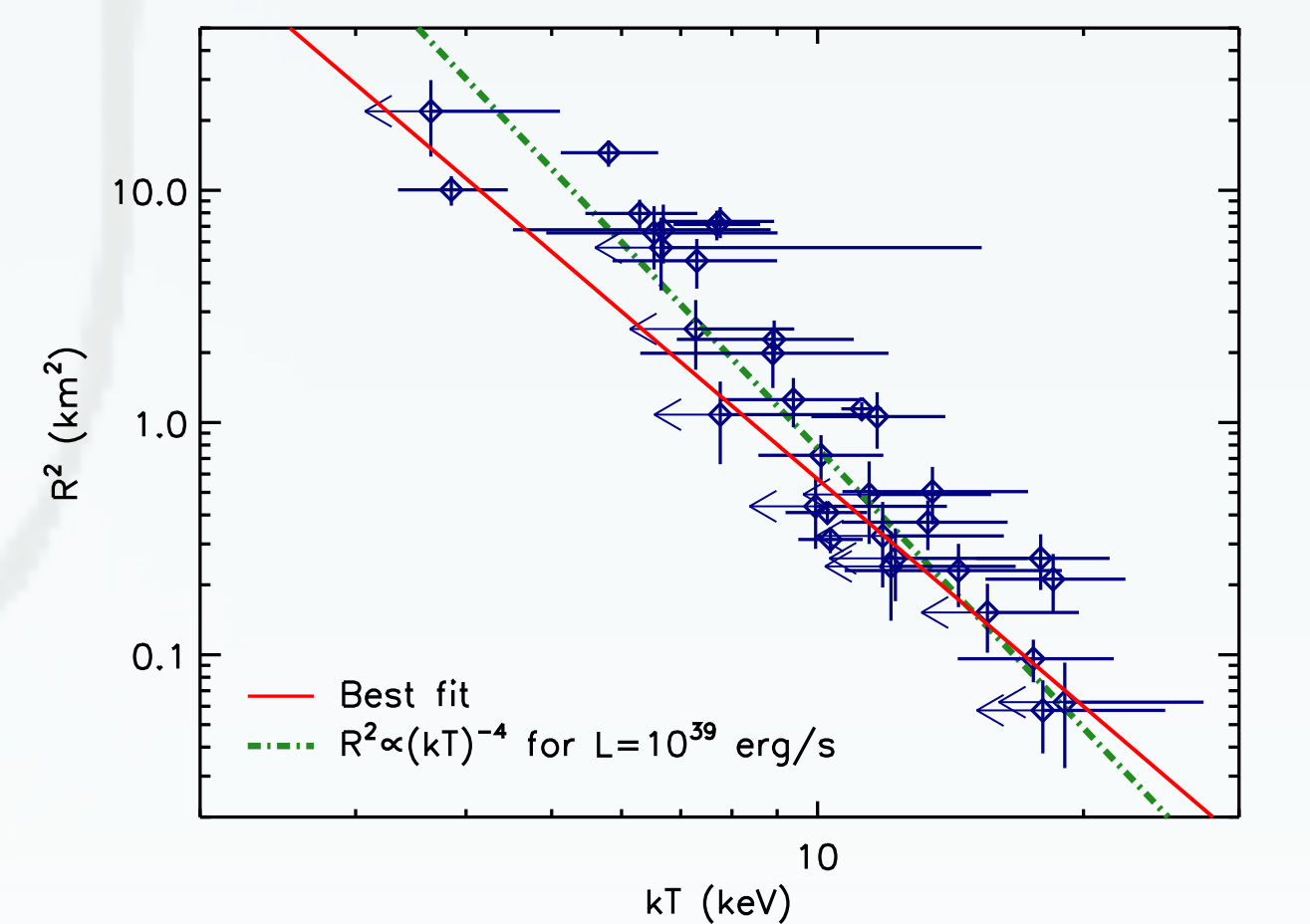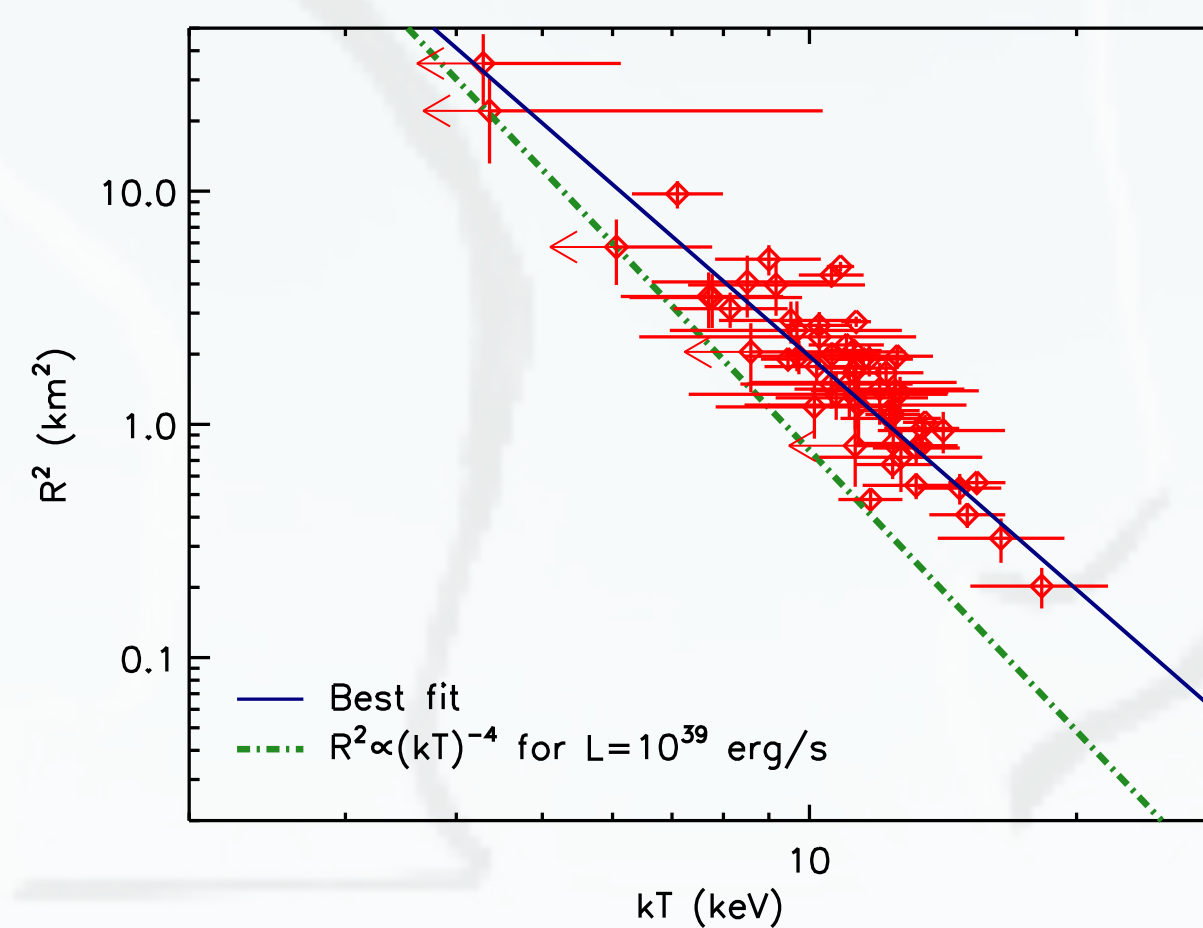

Fig6: Black body emitting area (R^2) vs. kT for Swift J1818 bursts (left) and PSR J1846 bursts (right). The best fit lines are shown as solid lines. We find that bursts from both sources roughly follow the Stefan-Boltzmann, $R^2 \propto (kT)^{-4}$, shown with green dash-dot line, which corresponds to the luminosity of $L=10^{39}$ erg/s. The arrows indicate that the lower uncertainties of the kT values cannot be constrained.

[1] Gavriil, F. P., Gonzalez, M. E., Gotthelf, E. V., et al. 2008,466 Science, 319, 1802.
[2] Göğüş, E., Lin, L., Kaneko, Y., et al. 2016, ApJL, 829, L25.
[3] Lin, L., Göğüş, E., Roberts, O. J., et al. 2020a, ApJL, 902, L43.
[4] Ambrosi, E., Barthelmy, S. D., D'Elia, V., et al. 2020, GRB Coordinates Network, 27672, 1.
[5] Malacaria, C., & Fermi GBM Team. 2020, GRB Coordinates Network, 27674, 1.
[6] Evans, P. A., Gropp, J. D., Kennea, J. A., et al. 2020a, GRB Coordinates Network, 27373, 1.
[7] Bernardini, M. G., D'Avanzo P., Klingler, N. J., et al. 2020, GRB Coordinates Network, 28055, 1.
[8] Barthelmy, S. D., Gropp, J. D., Kennea, J. A., et al. 2020, GRB Coordinates Network, 27696, 1.
[9] Gronwall, C., Gropp, J. D., Kennea, J. A., et al. 2020, GRB Coordinates Network, 27746, 1.
[10] von Kienlin, A., Gruber, D., Kouveliotou, C., et al. 2012, ApJ, 755, 150.

SCAN ME