A Preliminary Analysis of Complex Gamma-Ray Burst Pulses:

Independent Verification and Hakkila & Preece (2014) and Contributions to a Gamma–Ray Burst Catalog

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Abstract

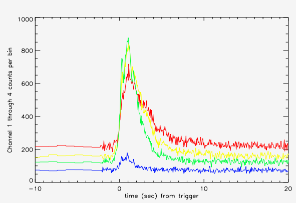
We present a preliminary analysis of previously unstudied gamma-ray burst pulses. Our sample consists of gamma-ray bursts observed between December 19, 1995 and February 2, 1997 by the Burst and Transient Source Experiment (BATSE) on NASA's Compton Gamma-Ray Observatory. We found that the observable properties of these pulses are consistent with those of previously isolated pulses. We also announce the discovery of two exceedingly long individual pulses representing either the tail of the duration distribution or a separate pulse subclass.

Introduction

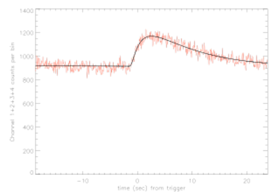
Gamma-Ray Bursts (GRBs) are bright flashes of gamma and x-ray emission observed from random directions on the sky about once a day. Long GRBs (with durations exceeding 2 seconds) are believed to originate from core collapse supernovae while Short GRBs (less than 2 seconds long) are thought to result from merging neutron stars. The emission from GRBs is beamed and highly relativistic. Each burst is composed of one to dozens of individual pulses. Pulses evolve from hard (dominated by higher energy photons) to soft (dominated by lower energy photons) on timescales corresponding to the pulse durations. Pulse rise times are generally shorter than pulse decay times; the rise of rise to decay times can be used to define an asymmetry. Since pulses obey simple behaviors, it appears that studying them can lead to an understanding of GRB physics.

Methods

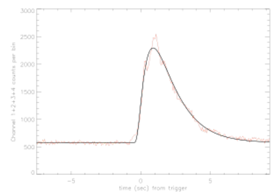
Using the IDL programming language, we attempt to fit each pulse of a burst with the Norris pulse fit model (Norris et. al 2005 ApJ-627324). The summed four energy channels, as well as the individual channels are fitted. The data from the fits are then entered into a catalog describing the properties of each pulse. Observable pulse properties include duration, peak flux, rise rate, decay rate, asymmetry, lag, and fluence. Plotting these properties against each other demonstrates underlying correlative characteristics and gives insight into the nature of Gamma-Ray Burst Pulses.



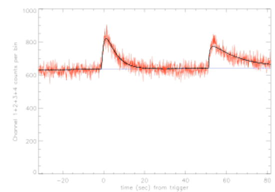
Sample Gamma-Ray Burst Pulse Fits



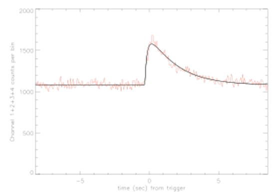
Burst 5387



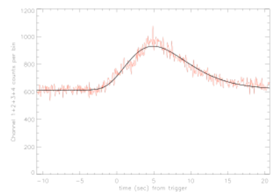
Burst 5417



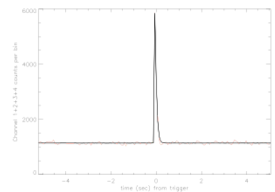
Burst 5457



Burst 5495

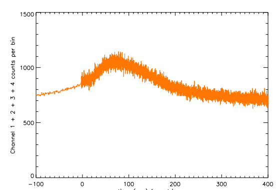


Burst 5531

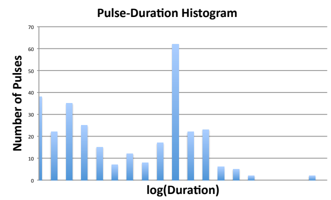


Burst 5561

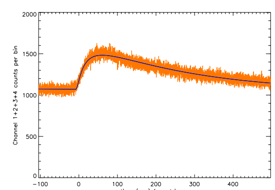
Long Pulses



Burst 6156
Estimated over 550 seconds
(Still attempting to fit)



300 Pulse Sample

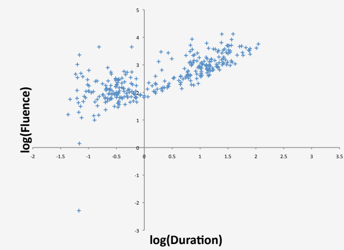


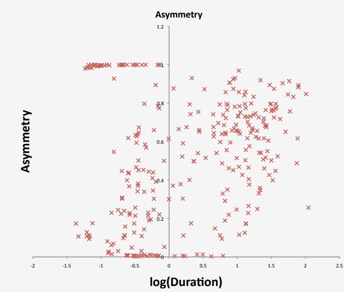
Burst 6526
862 seconds

Future Work

Currently, our goal is completion of a catalog that includes all pulses during BATSE's mission. Upon completion of the catalog, we will have a sufficient sample set of gamma-ray burst pulses to more deeply explore characteristics indicative of burst physics.

Comparisons





(Hakkila & Preece 2014 ApJ-78388)

Many observable pulse properties correlate with one another, suggesting that pulses originate from relatively simple underlying physics.

The Norris Pulse Shape

$$I(t) = A\lambda \exp[-\tau_1/(t - t_s) - (t - t_s)/\tau_2]$$

The Norris et al. (2005) pulse model provides a reasonable empirical fit to the shapes of GRB pulses. It successfully describes the general pulse shape and can be used in multichannel data.

Where:
A is the pulse Amplitude
τ_1 and τ_2 are characteristics of the pulse rise and decay
t is time since the trigger
t_s is the pulse start time
λ is the constant where
$\lambda = \exp[2(\tau_1/\tau_2)^{1/2}]$