



Swift: Catching Gamma Ray Bursts on the Fly

Launch: November 20, 2004

Swift Mission Science

Several times each day, explosions with peak energy of over one billion billion (1,000,000,000,000,000 or 10^{18}) Suns briefly outshine the brightest sources in our Universe in gamma-ray light. Called gamma-ray bursts (GRBs), these explosions are the most powerful events in the Universe. GRBs occur randomly in the sky, and they are over almost before they begin; they can last from less than 1 second to a few minutes in duration. This makes them very difficult to detect with ground-based telescopes that are needed to further study the bursts.

NASA's answer to this dilemma is Swift. The Swift mission is an international collaboration that assists scientists in studying many types of gamma-ray emitting objects in the Universe, including active galaxies, black holes, and pulsars. Swift's primary goal is to detect and observe GRBs in a multitude of wavebands: gamma-ray, X-ray, optical, and ultraviolet. By quickly (within seconds) nailing down the location of GRBs, astronomers will be able to better study these enigmatic explosions.

The main mission objectives for Swift are to:

- Determine the origin of GRBs;
- Classify GRBs and search for new types;
- Determine how the GRB blastwave evolves and interacts with the surroundings;
- Use GRBs to study the early universe; and
- Perform the first sensitive hard X-ray survey of the sky.

Catching bursts on the fly

Three instruments work together to accomplish the mission objectives:

- **Burst Alert Telescope (BAT):** The BAT is designed to sense a burst as it occurs. Once it detects the burst, Swift autonomously changes position to point the other two Swift telescopes at the burst within 75 seconds—fast enough to observe the afterglows and parts of the longer bursts.
- **X-Ray Telescope (XRT):** Once the BAT detects a GRB, the spacecraft slews to bring the new GRB into the XRT's field-of-view. The XRT measures the rate and amount of energy of the GRBs and afterglows in the X-ray band.
- **The Ultraviolet/Optical Telescope (UVOT):** As with the XRT, once the BAT detects a new GRB, the spacecraft slews to bring it into the UVOT's field of view. It will help scientists better localize the burst, determine its distance, and study the burst's afterglow.

Swift's multiwavelength observations of GRBs and afterglows are simultaneous. The XRT and UVOT have co-aligned fields of view — meaning they both see the same area of sky — both of which are within the BAT field of view.

Swift's software allows the spacecraft, via the Tracking and Data Relay Satellite System (TDRSS), to immediately contact the Gamma-Ray Burst Coordinates Network (GCN) at NASA's Goddard Space

Flight Center in Greenbelt, MD, with gamma-ray burst locations from the instruments. The GCN is now broadcasting the results over the Internet to all interested parties so that additional telescopes, both ground- and space-based, can assist with observations. The mission operations center for Swift is located at Penn State University.

Swift, a medium-class explorer mission, is managed by NASA's Goddard Space Flight Center. Swift was built in collaboration with national laboratories, universities, and international partners, including Penn State University, Los Alamos National Laboratory, and Sonoma State University in the USA; Mullard Space Science Laboratory and the University of Leicester in the UK; the Brera Observatory in Italy; the Italian Space Agency; and the ASI Science Data Center.

Educational Activity

GRBs are the most powerful phenomena in the Universe today! Examine the chart below to see how the light from GRBs compares to other sources of light energy, and then answer the questions below the chart.

Peak Power (Joule/sec)

Light Bulb: 10^2
Campfire: 10^4
Nuclear Power Plant: 10^9
H-bomb (1 megaton): 10^{15}
Sun: 10^{26}
Supernova: 10^{36}
GRB: 10^{44}

1. How many Suns would you need to generate the same peak power as a GRB?
2. How many times more powerful is a gamma-ray burst compared to a standard light bulb?
3. How many hydrogen bomb explosions would it take to equal a single GRB?

Answers:

- 1) You would need 10^{18} Suns to equal the power output of a single gamma-ray burst. That's one billion billion (1,000,000,000,000,000 or 10^{18}) times the Sun's power!
- 2) A GRB is 10^{42} times as powerful as a bright (100 Watt) household light bulb, but they are so far away they appear to be much dimmer.
- 3) It would take 10^{29} hydrogen bombs to equal the devastation of a single GRB. That is the same as exploding three million bombs every second for a million billion (1,000,000,000,000,000 or 10^{15}) years, far longer than the current age of the Universe!

Related educational activities can be found on the Web at:

<http://swift.sonoma.edu/education/index.html>

http://imagine.gsfc.nasa.gov/docs/teachers/lessons/swift_grb/how_far.html

<http://imagine.gsfc.nasa.gov/docs/teachers/gammaraybursts/gammaraybursts.html>

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