NASA Facts

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Swift

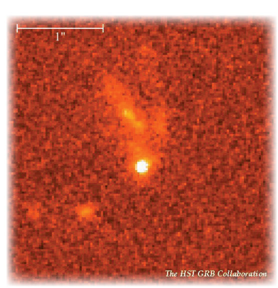
Catching Gamma Ray Bursts on the Fly

Catching Gamma-Ray Bursts on the Fly

Gamma-ray bursts are the most powerful explosions in the Universe other than the Big Bang. They occur several times per day, yet scientists still have only patchy details about what causes them. Each burst likely signals the birth of a new black hole – perhaps either through a massive star explosion or a fantastic merger between neutron stars or black holes.

Now there's a satellite designed to capture and analyze these bursts, some of which last only for a few milliseconds. NASA's Swift mission is a three-telescope space observatory. One of the telescopes will detect gamma-ray bursts; the other two will scrutinize the afterglow of the burst. Swift is a unique multi-wavelength mission. Its three telescopes span the gamma-ray, X-ray, ultraviolet and optical light bands, a swath of the spectrum over a million times wider than what the Hubble Space Telescope detects.

Artist's Illustration of Swift



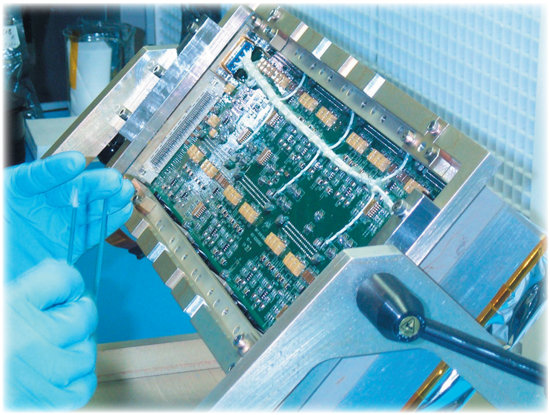
Hubble Image of GRB 990123

Duty Calls, Swift Responds:

Swift is the first mission to focus on studying the burst afterglow, a phenomenon discovered in 1997. Within seconds after detecting a gamma-ray burst, Swift will relay an accurate burst position to scores of orbiting and ground-based observatories so that they can observe the afterglow before it fades. The message goes out literally via e-mail and cell phones to scientists and amateur astronomers. Swift is also in contact with ground-based robotic telescopes waiting for Swift's commands.

Swift itself will focus its X-ray and UV/optical telescopes on the afterglow within about a minute. This enables Swift to determine distances for most of the bursts that it detects and provide detailed multi-wavelength light curves for the duration of the afterglow. Time is of the essence. Many bursts last about 10 seconds; the longest last about a minute. Once they are gone, the afterglows are hard to find. And the afterglows, like a crime scene, contain all the evidence about the burst. Scientists have yet to find an afterglow of a short burst (less than 2 seconds). Maybe there is no afterglow; maybe we're just not fast enough. Swift will lead to the detection of short-burst afterglows, if they exist, and determine whether they are intrinsically different from longer bursts.

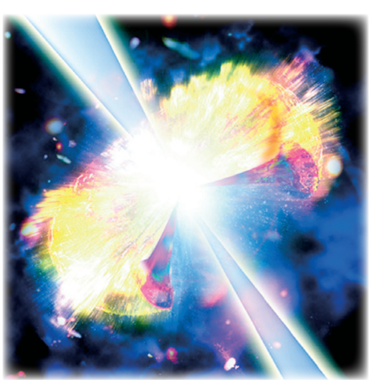
Swift Electronics Testing



Importance of Afterglow Measurements:

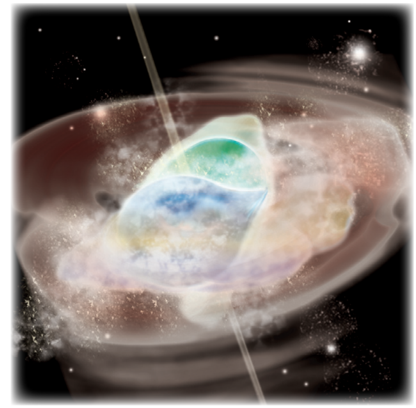
Distances determined from gamma-ray burst afterglows have enabled scientists to understand that these bursts originate very far away from us. In fact, the bursts may be located in the most distant galaxies we can observe. The power they produce each second is truly extreme, about 10^{50} – 10^{51} ergs, compared to the Sun's 4 x10^{33} ergs. Each gamma-ray burst is like a billion billion suns.

Many models have been proposed to explain gamma-ray bursts and their afterglows. What remains bewildering is the sheer diversity of the bursts. Some last for only a few milliseconds. Others last upwards of a minute. Some produce afterglows. Some are dominated by X-ray photons (light particles). Some show traces of iron atoms, a sign of a star explosion. Scientists indeed joke that if you've seen one gamma-ray burst, you've seen *one* gamma-ray burst.



Hypernova Illustration

The large sample of bursts that Swift will collect will enable scientists to test theories and, for the first time, perform multi-wavelength observations of the very short bursts, which have eluded ground-based observers. We may find that different kinds of bursts are caused by different origins, such as mergers of orbiting neutrons stars or gigantic stellar explosions known as hypernovae.



Neutron Star Merger Illustration

Astronomy and Physics Lessons:

Understanding gamma-ray bursts will reveal new insights about the Universe. Most bursts originate at cosmological distances, which means they ignited billions of light years away when the Universe was much younger. They act like beacons shining through everything along their paths, including the gas between and within galaxies along the line of sight.

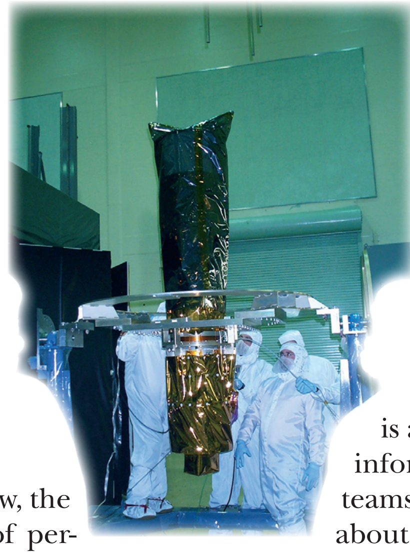
Some bursts may be from the first generation of stars. If so, we can begin to map out early star formation, which has not yet been done. Also, if gamma-ray bursts truly signal the birth of a black hole, scientists can at last measure the black hole formation rate in the Universe.

Gamma-ray bursts are laboratories for extreme physics. The explosions create blast waves that accelerate matter to nearly the speed of light. Such conditions cannot be reproduced on Earth, but scientists can watch and learn from afar.

Swift Instrumentation:

The main instrument onboard Swift is the Burst Alert Telescope (BAT). The BAT has a wide field of view and will detect and locate about two gamma ray bursts per week, relaying a 1- to 4-arcminute position to the ground in about 20 seconds. As it is relaying this information, Swift is turning so that its other two instruments – X-ray Telescope (XRT) and the UltraViolet/Optical Telescope (UVOT) – have a direct view of the afterglow... and maybe even part of the burst itself! The XRT and UVOT will determine the position of the burst to within arcseconds and also measure the distance to the source.

UVOT



After the burst fades or is out of view, the BAT will resume its "other job" of performing a sensitive all-sky survey in higher-energy (hard) X rays at the 15-150 keV energy level. This will be at least 20 times more sensitive than previous measurements and should uncover more than 400 supermassive black holes that are obscured at lower energies.

Swift

Support on the Ground and in the Sky:

Swift is connected to the Gamma-ray Burst Coordinates Network (GCN), a largely automated system to relay burst information in real-time to scientists around the world.

Swift is one of five satellites that relays gamma-ray burst activity to the GCN. The GCN distributes Swift information via e-mail to scientists and often to robotic telescopes directly. The robotic telescopes are dedicated to the gamma-ray burst hunt and, because they react immediately to an alert, offer the opportunity to catch an image of the burst while it is occurring. The GCN is also a repository of current burst information, a place where science teams post what they have learned about the burst, usually several times a day for the biggest and most exciting bursts. Relying on this GCN information, scientists at major observatories – such as the Keck Observatory in Hawaii, the Hubble Space Telescope and the Spitzer Space Telescope – will often turn these world-class instruments to study the regions surrounding the gamma-ray burst in the hours and days after an event.

Included in this Swift science network are over 30 follow-up teams spread out across the southern and northern hemispheres. The teams cast a wide net to ensure that no burst detected by Swift will go unstudied because of daylight, clouds or viewing angle. The GCN is a resource available to schools, science museums and anyone with an Internet connection.

BAT

XRT

Follow Up Team Observatories and Facilities:

AEOS Telescope (Hawaii)
ARAGO Telescope (Antarctica)
ARC Telescope (New Mexico)
Brera Observatory (Italy)
ESO (La Silla, Paranal, VLT)
ESA's INTEGRAL mission
Fast Alert MachinE (Italy)
Faulkes Telescope Project (Hawaii and Australia)
Galileo National Telescope (La Palma)
Hobby-Eberly Telescope (Texas)
Isaac Newton Telescopes (La Palma)
KAIT (California)
W. M. Keck Observatory (Hawaii)
Large Binocular Telescope (Arizona)
LIGO (Louisiana and Washington)
Liverpool Telescope (La Palma)
McDonald Observatory (Texas)
Milagro Gamma-ray Observatory (New Mexico)
NASA (IRTF, Hubble & Spitzer Space Telescopes)
NOAO (CTIO, KPNO)
Nordic Optic Telescope (La Palma)
Okayama Observatory (Japan)
Rapid Eye Mount Telescope (Chile)
ROTSE-III (New Mexico)
SARA Observatory (Arizona)
South African Large Telescope
Super-LOTIS (Arizona)
TAOS Telescope (Taiwan)
TAROT Telescope (France)
Tenerife Observatory
U.S. Naval Observatory (Arizona)
VERITAS Observatory (Arizona)
WASP Telescope (La Palma)
WIYN Observatory (Arizona)
Wyoming Infrared Observatory

Swift Mission

Lifetime	*2 years minimum*
Height	*5.64 m*
Mass	*1470 kg*
Power	*1040 Watts*
Launch vehicle	*Delta 7320*
Orbital inclination	*21 degrees*
GRB Position Accuracy	*0.3-5 arcsec*
Repointing Time	*20-75 seconds*

Lead Institutions Involved

Area of Support

NASA Goddard Space Flight Center, USA
- BAT instrument, Project Management

Penn State University, USA
- XRT, UVOT, Operations

University of Leicester, UK
- X-ray Telescope and Detectors

Mullard Space Science Lab, UK
- UVOT Assembly

Brera Observatory (OAB), Italy
- X-ray mirrors for the XRT

Italian Space Agency, Italy
- Ground Station Support

Los Alamos National Laboratory, USA
- BAT Instrument Flight Software

General Dynamics C4 Systems, USA
Spectrum Astro Space Systems
- Spacecraft Vendor

Sonoma State University, USA
- Education and Public Outreach