

Gamma-Ray Bursts

A BRIEF HISTORY



October 1963: The U.S. Air Force launches the first in a series of "Vela" satellites carrying X-ray, gamma-ray and neutron detectors in order to monitor any nuclear testing by the Soviet Union or other nations in violation of the just-signed nuclear test ban treaty.

July 2, 1967: The Vela 4a,b satellite makes first-ever observation of a gamma-ray burst. The actual determination would come two years later in 1969. The results would not be declassified and published until 1973.

March 14, 1971: NASA launches the IMP 6 satellite. Aboard the satellite is a gamma-ray detector. Although the main purpose of the instruments was not to detect for gamma-ray bursts (GRB), it nevertheless inadvertently observes them while monitoring solar flares.

September 1971: The Seventh Orbiting Solar Observatory (OSO-7) is launched. It carries an X-ray telescope designed to measure hard (very energetic) X-rays from sources across the sky. OSO-7 also includes a gamma-ray monitor.

1972-1973: Los Alamos scientists analyze various Vela gamma-ray events. They conclude that gamma-ray bursts are indeed "of cosmic origin." They publish their findings concerning 16 bursts as observed by Vela 5a,b and Vela 6a,b between July 1969 and July 1972 in the *Astrophysical Journal* in 1973.

1974: Data from Soviet Konus satellites is published, confirming the detection of these bursts of gamma rays.

1976: The start of the Interplanetary Network (IPN), a set of gamma-ray detectors placed on spacecraft studying the Sun and planets. These detectors work in unison to locate gamma-ray bursts through a process of triangulation. By localizing the sources of GRBs to a few arc minutes, the IPN shows that these sources are not known sources of interest, such as X-ray emitters. The IPN continues today.

March 5, 1979: An unusual gamma-ray transient is found, later localized to the N49 supernova remnant in the LMC. This causes a controversy that lasts for over a decade: One side maintains accidental coincidence (the thought was that GRBs could not come from anything as distant as the LMC galaxy), while the other maintains two classes of sources exist, and that this is a separate one from GRBs. Later study of Soft Gamma Repeaters by ASCA proves the latter to be correct. (And, GRBs do come from very distant sources.)

April 5, 1991: NASA launches the Compton Gamma Ray Observatory. Among its payload is the Burst And Transient Source Experiment (BATSE) instrument, which detects over 2,700 gamma-ray bursts in nine years. BATSE data proves that gamma-ray bursts are uniformly distributed across the sky, not concentrated along the plane of the Milky Way. This means that gamma-ray bursts originate

far outside of the Milky Way galaxy. This disproves the galactic neutron theory. It also suggests that gamma-ray bursts have mind-boggling energies associated with them in order to be detectable across the entire observable universe. This marks a paradigm shift; gamma-ray bursts are now viewed as cosmological.

December 30, 1995: NASA launches the Rossi X-ray Timing Explorer, designed to study how the emission lines of X-ray emitting sources change with time. This will be used subsequently to study the X-ray afterglow of gamma-ray bursts.

April 30, 1996: The BeppoSAX satellite, a joint collaboration of the Italian Space Agency and the Netherlands Space Agency, is launched.

February 28, 1997: Using BeppoSAX, astronomers looking at GRB979228 detect an X-ray afterglow associated with a gamma-ray burst for the first time. This begins the era of studying GRB afterglows.

January 23, 1999: The afterglow of GRB990123 is detected within seconds of the initial burst. Based on careful analysis, astronomers determined that the energy is channeled (beamed) in narrow jets and that we detect GRBs only if the jet is aimed along our line of sight. The energy output of GRB990123 is put at 10^{43} watts — 1,000 times more luminous than quasars and one hundred quadrillion times more luminous than the Sun.

July 5, 1999: GRB990705 is detected. Analysis of the emission lines from the afterglow shows an iron-absorption feature that is characteristic of a supernova.

December 12, 1999: Observations of emission lines from GRB991216 afterglow from the Japanese X-ray satellite ASCA and NASA's Chandra X-ray Observatory detect iron lines. This helped pinpoint a distance to the burst.

January 21, 2000: Peter Meszaros, Bohdan Paczynski and Martin Rees are each awarded the Bruno Rossi Prize by the High Energy Astrophysics Division of the American Astronomical Society for their work on gamma-ray bursts.

March 26, 2000: BATSE detects its final burst, number 2,704.

October 9, 2000: NASA's High Energy Transient Explorer (HETE) is launched. The international, MIT-built HETE was designed to detect and rapidly pinpoint the location of gamma-ray bursts.

December 11, 2001: GRB 011211 is detected. The European Space Agency's X-ray Multi-Mirror satellite finds evidence of silicon, sulfur, argon, and other elements in the shell of gas surrounding the burst. Such elements are typically associated with supernovae.

October 4, 2002: HETE detects a burst observed so quickly by other telescopes that scientists find evidence of the death of a massive star and the birth of what appears to be a black hole in its place.

October 17, 2002: The European Space Agency launches INTEGRAL, a gamma-ray observatory containing a burst detector. INTEGRAL detects several bursts during its first months of operation.



December 23, 2002: HETE detects the first "dark" gamma-ray burst with an afterglow. Such bursts, accounting for roughly half of all GRBs, were thought to be devoid of optical afterglows. This afterglow disappears within 2 hours -- meaning that if the afterglow hadn't been detected as quickly as it had, this GRB would've been labeled "dark". Perhaps no burst is truly dark if observed fast enough.

March 19, 2003: NASA announces compelling evidence that long-duration gamma-ray bursts (lasting over 10 seconds) form from the death of massive stars and simultaneous creation of black holes.

December 2003: NASA's Swift satellite is due to be launched. Swift will carry instruments designed to measure both GRBs and their afterglow in X-ray, ultraviolet and optical light wavelengths.

September 2006: The Gamma Ray Large Area Space Telescope (GLAST) will carry an instrument to detect gamma-ray bursts with photons thousands of times more energetic than what Swift detects.

