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Cite as: AIP Conference Proceedings **384**, 977 (1996); https://doi.org/10.1063/1.51630
Published Online: 12 May 2008

J. T. Bonnell and R. W. Klebesadel

A Brief History of the Discovery of Cosmic Gamma-Ray Bursts

J.T. Bonnell,[1] R.W. Klebesadel[2]

[1] *NASA/Goddard Space Flight Center, Greenbelt, MD*
[2] *Los Alamos National Laboratory, Los Alamos, NM*

The discovery of cosmic gamma-ray bursts, based on an analysis of data produced by the Vela defense satellites was announced in Ap.J. letters in 1973 by Klebesadel, Strong, and Olsen. The story of the discovery begins 10 years earlier, in October of 1963, when the US Air Force launched the first in this series of satellites inspired by a nuclear test ban treaty. Interest in the events surrounding this discovery has been piqued by the recent public debate on the distance scale to the burst sources. Details of the Vela program to detect nuclear detonations and general circumstances surrounding the discovery of gamma-ray bursts of "cosmic origin" are presented.

THE VELA PROGRAM

In October of 1963 the US Air Force launched the first in a series of satellites inspired by a recently signed nuclear test ban treaty. Signatories of this treaty agreed not to test nuclear devices in the atmosphere or in space. These "Vela" (from the Spanish verb velar, to watch) series satellites were part of an unclassified research and development program whose goal was to develop the technology to monitor nuclear tests from space and give the US a means of verifying the conditions of the treaty (1).

The satellites were launched and operated in pairs with two identical satellites on opposite sides of a circular orbit 250,000 kilometers in diameter (about a 4 day orbit) so that no part of the Earth was shielded from direct observation. The Vela satellites carried x-ray, gamma-ray, and neutron detectors as a basic instrumentation complement along with a variety of optical and EMP detectors as well as instruments designed to monitor the space environment (2), (3). The instruments were designed and built by teams of workers at the Los Alamos Scientific Laboratory (now LANL) and Sandia Laboratories of Albuquerque NM, who were specifically assembled and commissioned for the Vela mission.

The x-ray detectors were intended to directly sense the flash of x-rays from a nuclear blast. Although most of the energy of a bomb blast in space would be directly visible as an x-ray flash (2) a simultaneous indication by the gamma-ray detectors would provide a confirming signature of a nuclear event. Additional confirmation would come from the detection of neutrons. Further, the Vela designers were aware that detonating a nuclear bomb behind a thick shield or on the far side of the moon would effectively hide the initial flash of x-rays from the satellites' view. Hence the gamma-ray detector logic was designed to look for delayed hard gamma-radiation resulting from the cloud of radioactive material blown out after the nuclear blast. This blast cloud could not be totally shielded from view and would expand rapidly. Because of this design, the gamma-ray detectors were, coincidentally, able to record gamma-ray burst time histories.

The Vela satellites generally performed well and greatly exceeded their expected operational lifetimes (1). The satellites' capabilities were steadily improved with each launch. In particular, Vela 5 a and b (launched in 1969) and 6 a and b had sufficient timing accuracy that they could coarsely determine directions to the triggered events. For these later satellites, the light travel time from one spacecraft to another, across the orbital diameter (around 1 second), was greater than the resolution time of the event's onset (about 0.2 seconds). The direction angle to the event with respect to the line between a pair of satellites could thus be determined (to about 1/5th of a radian or 10 degrees) based on the difference in trigger times for the two satellites. Direction angles for a single event observed by multiple pairs of satellites could then be combined to determine one or two possible directions for the source of the event.

GAMMA-RAY BURST DISCOVERY

In 1965, with the construction and launch of the Vela 3 satellites, one of the authors (R.K.) assumed the continuing programatic responsibility for the x-ray and gamma-ray instruments at Los Alamos Scientific Laboratory. Files of events which triggered the detectors but were clearly not signatures of nuclear detonations were kept and analyzed. Many were identified as false triggers but, with the improved capabilities of the later Velas, R.K. along with Los Alamos colleagues Ian Strong and Roy Olsen were able to deduce the directions to a small number of confirmed, "real" gamma-ray events with sufficient accuracy to rule out the Sun and Earth as sources. Thus, it was established that the gamma-ray events were "of cosmic origin". In 1973, this discovery was announced in an Astrophysical Journal Letter (4). The paper discusses 16 cosmic gamma-ray bursts (GRBs) observed by Vela 5 and Vela 6 satellites between July 1969, and July 1972.

Using a hard x-ray detector on board IMP-6 intended to study solar flares, Tom Cline and Upendra Desai of NASA/GSFC were the first to confirm this finding and provide some spectral information that showed that the burst spectra peaked at gamma-ray energies (5). Thus the events were not simply the high energy tail of an x-ray phenomenon. A collimated gamma-ray telescope on board OSO-7 (6) was also able to confirm a direction to one of the events, supporting the original conclusions of cosmic origin. These confirming results, published close on the heels of the original discovery, gave the whole scenario an aura of enhanced mystery. The excitement created in the astro-

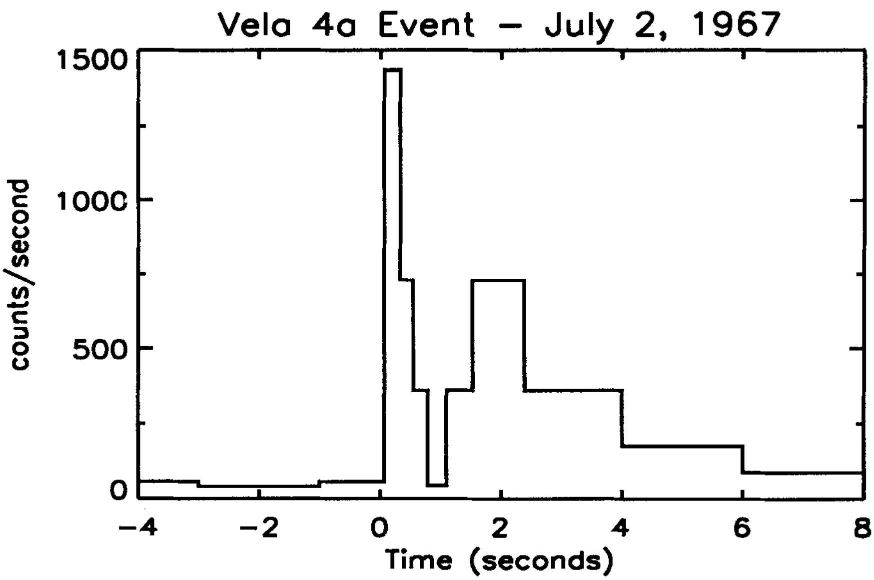

FIG. 1. The Vela 4a time history of the first observed gamma-ray burst.

nomical community was evidenced by a burst of publications of instrumental and theoretical papers on the newly discovered "cosmic gamma-ray bursts".

FIRST OBSERVED GAMMA-RAY BURST

In 1969, while looking back over Vela 4 data just prior to the launch of Vela 5, R.K. and Roy Olsen found an event recorded by the Vela 4s on July 2, 1967 which also triggered the still operational Vela 3 satellites. The event appeared to be a cosmic gamma-ray burst but at the time the constellation of satellites did not have sufficient timing resolution at the trigger to make a good determination of direction to the burst source. In retrospect, this event had a time history similar in appearance to the later recognized cosmic bursts. It is believed that this event represents the "first observed gamma-ray burst" and the Vela 4 a data used to construct the time history is shown in Figure 1 (see also (7)). No earlier observation of a similar event is known.

Since the Vela program was essentially an unclassified research and development effort intended to determine the feasibility of detecting nuclear explosions in space, neither the data nor the discovery of GRBs were classified information. However, the earlier Velas were subject to large false trigger rates and the delay between "discovery" in 1969 and publication in 1973 was based largely on the desire to confirm the results through exhaustive analysis and further observations with multiple Vela satellites.

Acknowledgements: Ian Strong, Tom Cline, and Ed Fenimore are thanked for enlightening conversations and comments.

RELATED URLS

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