COMMENT

The Weapons-Test Connection

by Roger C. Eckhardt

At the test ban summit meetings in 1959, Stirling Colgate watched the attention of the delegates drifting off the technical discussion onto thoughts of wine and women. He refocused their attention with one abrupt question: Would the gamma rays from a supernova trigger the detectors in the proposed test-surveillance satellites? With this question, Colgate connected the political goal of test surveillance with the scientific goal of understanding cosmic phenomena. In the satellite detection of gamma rays this connection has persisted now for two decades. However, it has been perceived in different ways with different consequences by different groups of people.

At one extreme is the opinion represented by the *National Enquirer* story that claimed gamma-ray bursts were evidence of intergalactic star wars. The Air Force Vela satellites were in orbit to watch for nuclear-weapons tests. The alarm bells in these spacecraft were being set off by bursts of gamma rays with an intensity that amazed even the supposedly implacable scientists at Los Alamos. However, the bursts were coming from outer space. Ergo, intergalactic star wars.

A few members of the astrophysics community have viewed the connection between political and scientific goals in another light, reasoning as follows. Gamma-ray bursts weren't "discovered" until almost ten years after the launch of the first pair of Vela spacecraft. Ergo, the classified nature of the surveillance mission must have impeded the use of Vela data for scientific purposes.

What of the point of view of the scientists at Los Alamos closest to the discovery of gamma-ray bursts? Early in the Vela program, data from the gamma-ray detectors were searched for enhanced signals in the vicinity of the times of reported supernovae in distant galaxies. When these searches proved fruitless, the idea that an unknown and startlingly different phenomenon might be hiding in the data could not be examined with high priority by the people involved. During the ten-year span they, instead, pursued an answer to a broader version of Colgate's original query: Could a natural background event mimic the signal of an exe-atmospheric weapons test? Although this question was directed primarily toward the political goal, the natural scientific drive to eliminate even minor doubts resulted eventually in a surprise—the discovery of gamma-ray bursts. In truth, the time span was due, not to classification, but to the fact that gamma-ray bursts were totally unexpected.

In the 1960s the primary task at Los Alamos was to monitor the state of health of the Vela systems. For this purpose, a review of the complete record of the original data was unnecessary. In fact, since the Vela 1 and 2 satellites could be monitored only part of the time, only a fraction of the potential data was being transmitted to the Air Force ground-control stations. However, by 1967 gamma-ray detectors had been designed that were more sensitive and that automatically recorded the signal whenever an increased counting rate occurred. These detectors, aboard the Vela 3 and 4 satellites, created a new problem because large numbers of background events or false alarms were now being detected. The events would be recorded, then later flagged for attention by the satellite when they were transmitted. But which of the signals were instrumental glitches and which were caused by natural phenomena?

Instruments to help determine natural background events had also been placed aboard Vela satellites, starting with the third launch. These included a collimated x-ray detector, an instrument designed to monitor solar x rays, and detectors sensitive to high- and low-energy charged particles. (In ensuing years, the charged-particle instruments were to make significant measurements of the characteristics of the magnetosphere.) While some of the signals were identified by these instruments as, say, due to the local effects of charged particles, many were left unexplained.

Also, Ray Klebesadel, a Los Alamos scientist, was beginning to suspect that certain occasional events were being detected at about the same time at more than one satellite. His suspicion, if verified, would indicate the occurrence of a nonlocal phenomenon. To discriminate such nonlocal events from other signals, all data had to be referred to a common time by accounting in each satellite for drift in the electronic oscillator time base, instrument rise time, data recording delays, transmission delays, and so forth. Klebesadel, with Roy Olson, developed a computer data analysis program for this purpose, but only after lengthy efforts were they able to convince themselves that the timing had, indeed, been placed on a reliable absolute basis.

These changes, both in instruments and in data analysis, caused important changes in how the data were viewed. Previously, the data records were examined only close to the times of known cosmic events. Now valid gamma-ray signals could be cataloged and attempts made to find related cosmic events at the times of the signals. Also, a new method of sampling the universe had unknowingly been implemented. The immediate, practical reason to develop detectors that recorded nothing permanent until triggered by a large signal was the fact that detector memory was too limited to record all data between transmissions. But this automatic feature provided the capability needed to track intermittent, highly variable gamma-ray bursts, as well as serving as a prototype for other instruments used to study the universe at high photon energies.

Despite these changes, it was still difficult to realize that a new gamma-ray phenomenon was, in fact, occasionally being recorded. For example, from May 1967 to August 1968 a manual search of the data revealed that the Vela 4A satellite had recorded 73 events while the 4B satellite had recorded about 100. Of these, only 8 occurred at both spacecraft within 10 seconds or less, and 7 of these recorded counts that were only slightly greater than the steady-state background. Five of the weak signals could be correlated with solar flares. This left three signals of unknown origin including the one strong signal. This latter signal not only was about two orders of magnitude above background, but was recorded by both Vela 4 detectors with the same double-peaked pulse shape, and was even seen by Vela 3 detectors.

In retrospect, the event recorded on July 2, 1967 has been recognized as the first discovered gamma-ray burst. However, in June of 1970 it was felt that the observation of this single event, while extremely interesting, did not merit publication because of many remaining doubts. For instance, might cosmic rays, a solar event, or some other phenomenon associated with the earth or the solar system still be found to be responsible for this single event? Also, there was no evidence of any other astrophysical phenomenon taking place at about the same time as the gamma-ray event. The Los Alamos scientists were worried because, if an event outside our solar system could cause such an intense burst of gamma rays, it seemed there should be evidence at other wavelengths, including the visible.

The Vela 5 satellites were launched in 1969, but the instruments, although greatly improved in many respects, suffered an electronic anomaly that generated a large number of extraneous events. To deal with the copious routine data that were accumulating, automatic computerized scanning routines were obviously needed, Further lengthy efforts were made by Klebesadel and Olson to deal with this problem, including development of these systems for the Vela 6 spacecraft, launched in 1970. Only then was the search for simultaneous events continued, and a dozen bursts were resolved in quick succession.

One of the bursts seemed clearly to be of solar origin—might the others be also? Furthermore, a number of satellites were in orbit, but many events were recorded by only a fraction of the gamma-ray detectors. Each burst had to be examined and reasons found to explain why given detectors had not responded to the event. However, a time-of-arrival location technique applied to data from the four Vela 5 and 6 satellites in geocentric orbit was adequate to eliminate the major members of the solar system as source objects for many of the bursts. Finally, enough data were amassed in 1972 to eliminate nearly all doubts. A new astrophysical phenomenon had been discovered.

A paper announcing the discovery was submitted to *The Astrophysical Journal* by Ray Klebesadel, Ian Strong, and Roy Olson, and the results were discussed at a meeting of the American Astronomical Society in June 1973. Tom Cline at NASA Goddard Space Flight Center had also been moving toward similar conclusions based on strange signals detected by instruments aboard the International Monitoring Platform satellites.

In the last decade much has been learned about cosmic gamma-ray bursts; much remains to be learned. The effort to understand the gamma-ray burst has truly been international, involving satellites orbited for a variety of purposes. However, it is heartening that instruments originally designed to detect nuclear weapons tests eventually helped to reveal a complex and surprising natural phenomenon. ■