In the case of the longer wavelength radiation, however, the incoming photons are weak and ineffective when used in conjunction with the more common semiconducting materials. Even weakly bound electrons are held too tightly. Incoming photons may strike the electrons but lack the energy and momentum required to knock them loose.

The development of suitable detectors was a collaborative effort involving the National Aeronautics and Space Administration, university-based research groups, and the telescopes focal plane contractor, Rockwell International, Incorporated. Ultimately, the project succeeded in meeting the requirements of the detector specifications but not without first encountering some difficult challenges.

Several technical problems faced the developers. First, they had to identify a material in which the binding energy of the electrons was suitably matched to the energies of the incoming photons. Second, they had to produce the material with the desired composition. Finally, they had to fabricate a reliable device with high electrical quality and low noise interference, so that the relatively faint stream of photons arriving from deep space could be recorded by the telescope with good resolution.

Silicon, properly doped with impurity atoms, is a material commonly used for semiconductor devices and for infrared detectors of higher temperature sources (wavelengths shorter than 30 microns). A related element, germanium, was known to bind the electrons of the impurity atoms more weakly and, thus, was known to be more susceptible to far-infrared photon interactions. Unfortunately, while there was a well-developed industry associated with silicon, no comparable capability existed for germanium. Numerous trial and error attempts produced encouraging results but fell short of the required performance.

As launch deadlines neared, word of these detector development difficulties spread to Basic Energy Sciences researchers at Lawrence Berkeley Laboratory. Here, the Basic Energy Sciences program had long supported a unique facility aimed at exploring fundamental interactions between matter and photons in the far-infrared range. Here also was located another group of researchers supported by the Department of Energy's Office of Health and Environmental Research.

Both groups of researchers had done earlier collaborative work on germanium—an element which also happens to have a number of unique advantages for nuclear radiation detectors used in health and environmental protection fields. Certain crystals grown for other purposes, in fact, were already available for testing.

Within 2 weeks, the Lawrence Berkeley Laboratory collaborators had constructed a prototype detector and successfully demonstrated its capabilities in the Basic Energy Sciences far-infrared radiation laboratory. From this success and their prior experience with radiation detectors, the collaborators could infer: (1) the optimal mix and selection of materials and impurities, (2) procedures for making high quality and well-characterized gallium-doped germanium crystals, (3) the usefulness of sophisticated ion implantation techniques for low-noise electrical contacts, and (4) detailed methods for physically constructing the tiny devices.

This information was immediately shared with the National Aeronautics and Space Administration and its project participants. Shortly thereafter, Rockwell reported success in overcoming previous development barriers. Cornell University, using Lawrence Berkeley Laboratory techniques, produced half of the focal plane's far-infrared detectors.

Launch schedules were met and the Infrared Astronomical Satellite performed as planned. Four spectral bands were used. Two employed silicon detectors. Two others used the germanium detectors whose development had been aided by Basic Energy Sciences research and laboratory capabilities.

From the images captured by these detectors, the telescope clearly recorded and made visible the presence of previously unseen matter orbiting nearby stars. In each case, this matter appeared as a thick, material-laden disk, extending in radius a distance comparable to the orbits of our own outer planets.

This evidence is consistent with and suggestive of prevailing theories about the early formation of our own solar system, planets, asteroids, and moons. Its only apparent difference is one of time. The fact that such matter was found orbiting the first few stars viewed suggested, further, that its prevalence among stars in general was likely to be