presence of cold, dimly lit orbiting matter, ever so slightly warmed by a central star.

The telescope performed spectacularly. In the course of 1 year's operation, it identified 100,000 new stars, discovered 10,000 previously unknown galaxies, probed the dust-obscured heart of our own Milky Way galaxy, and spotted an unidentified comet. As it focused its eye on nearby stars, it also revealed the existence of orbiting matter, suggestive of early solar system formation.

Several of the key instruments that made these discoveries possible are called far-infrared detectors. They are capable of discerning radiant energy emissions from objects whose surfaces register temperatures hundreds of degrees Fahrenheit below zero.

Infrared radiation is a form of invisible light common to our daily lives. Although we cannot see it, we can feel it, as radiant heat given off by warm objects, or as the warm (and invisible) part of sunlight that falls on our skin. As a general form of light, it is called "infra" red (below red) because its characteristic energies and wavelengths lie just beyond the red or lower energy end of the visible spectrum. "Far" infrared refers to radiation furthest away from red.

Just as visible light comes in many colors, infrared radiation also has many variations. These variations, sometimes characterized by energy, and other times by wavelength, are closely associated with temperature. The hotter the object, the higher the energy of the emitted radiation, and the shorter its wavelength. Very hot objects, in fact, emit a spectrum of radiation with waves of sufficiently high energies and short wavelengths that some of them spill over into the visible spectrum. We see these objects as "red hot."

Although we may think of infrared radiation as "warm," all objects, even those at temperatures of extreme cold, give off detectable "heat." The emitted waves simply have lower energies and longer wavelengths.

For example, objects at room temperature emit radiation with relatively high energies and short wavelengths. Such wavelengths average about 10 microns (1 micron is one-millionth of a meter). The glaciers of Antarctica, whose temperatures may be −100° Fahrenheit (F), emit radiation with lower energies and longer wavelengths, on the order of 15 microns. Weather satellites, which map the cold (−250°F) upper cloud decks of the stratosphere, use infrared radiation with still lower energies and longer wavelengths on the order of 25 microns.

By the mid-1970's, infrared detectors in these ranges (wavelengths shorter than 30 microns) were well developed. As a happenstance of nature, most waves at the higher energies and shorter wavelengths propagate freely through air and water vapor, allowing many practical uses. Specially designed detectors, for example, locate objects in the dark, point out leaks in building insulation, target the heat signatures of enemy equipment on the battlefield, and sense minute variations in skin temperature caused by the rapid growth of tumor cells.

Waves at lower energies and longer wavelengths, by contrast, are strongly absorbed by air and water vapor. Moreover, few objects in our natural environment exist at three or four hundred degrees Fahrenheit below zero. For these reasons, both research and practical applications at this end of the infrared spectrum lagged.

Even so, it was clear that such temperatures were important to the further advancement and better understanding of space. In anticipation of our Nation's capability to launch heavy payloads into earth's orbit, a telescope was planned which could detect the longer wavelengths, once free from atmospheric hindrances. For the temperature ranges of interest, infrared radiation had wavelengths greater than 30 microns (−285°F). No existing detector had the required capabilities. New detectors had to be developed.

The technological approach chosen for the development of these early far-infrared detectors focused on a physical phenomenon known as photoconductivity. This phenomenon takes place when an incoming ray of light, or more precisely, a photon of infrared radiation, strikes the surface of a semiconducting material laced with so-called impurity atoms. Under special conditions designed into the material, some photons will interact with weakly bound electrons of the impurity atoms, knocking them out of their positions. If a voltage is applied to the material, the freed electrons will drift toward an electrical contact, giving rise to a current. This current can then be read by a sensitive meter.