p78-70178

NASA News

National Aeronautics and
Space Administration

Washington, D.C. 20546
AC 202 755-8370

(NASA-News-Release-78-165) SECOND HIGH ENERGY ASTRONOMY OBSERVATORY LAUNCH SET (National Aeronautics and Space Administration) 32 p CSCL 22A

N78-33130

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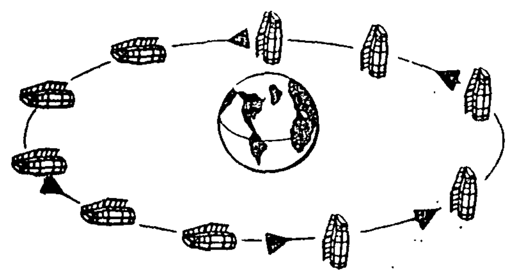
Press Kit

Project HEAO 2

RELEASE NO: 78-165



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Mailed:
November 3, 1978

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For Release:

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THURSDAY,
November 9, 1978

Don Worrell
Marshall Space Flight Center, Huntsville, Ala.
(Phone: 205/453-0035)

RELEASE NO: 78-165

SECOND HIGH ENERGY ASTRONOMY OBSERVATORY LAUNCH SET

NASA is preparing to launch its second High Energy Astronomy Observatory (HEAO), continuing a three-mission program to study some of the most intriguing mysteries of the universe -- pulsars, quasars, exploding galaxies and black holes in space.

HEAO 2 will be launched into Earth orbit atop an Atlas Centaur rocket from Kennedy Space Center, Fla., about Nov. 13.

-more-

Carrying a focusing X-ray telescope and a variety of sensitive instruments, HEAO 2 will maneuver and point for long periods of time at selected X-ray sources already identified by its predecessor, HEAO 1.

HEAO 1 was launched last year to conduct a general X-ray sky survey, and HEAO 3 will be launched in 1979 to collect celestial gamma ray and cosmic ray data.

These high-energy rays cannot be studied through Earth-based telescopes because of the obscuring effects of our atmosphere. The rays were observed initially by instruments on sounding rockets and balloons, and by small satellites which did not have the instrumentation capabilities required for high data resolution and sensitivity. These capabilities are now available in the HEAO satellite.

The "pictures" returned by HEAO 2 will be the first spacecraft-generated X-ray images of wide objects other than the Sun. (The Apollo Telescope Mount, which was part of Skylab, produced images of the Sun in the X-ray region.) HEAO 2's images, acquired by the X-ray telescope, will be converted to telemetry, then received and taped by ground stations. Eventually this telemetry will be reconstructed as photographs showing size, structure and detail of the objects viewed by HEAO.

Information returned by HEAO may provide clues to the nature of some of the "newest" and most mysterious celestial objects in the universe. This knowledge, in turn, could lead to a better understanding of the invisible high-energy universe and to new theories about energy production and high-density nuclear matter.

The first observatory is still operational, surveying and mapping X-ray sources throughout the celestial sphere and also measuring the low-energy gamma ray flux. The spacecraft can survey the entire sky in six months. Although HEAO 1 was designed for only a six-month lifetime, the quality of the data return was so excellent that an extension was authorized. The spacecraft is expected to remain active until it reenters Earth's atmosphere or depletes the onboard control gas supply, probably in early or mid-1979. Besides mapping the X-ray sky, the highly successful satellite has performed more than 300 pointing operations.

- HEAO 1 scientific results indicate that the map of X-ray sources will contain up to 1,500 sources when all data have been analyzed. This number would increase the previously known number of X-ray sources by a factor of four.

• A map of the diffuse celestial X-ray background has been completed. There is strong evidence that a major contributor to this background is a hot universal gas which may constitute a significant fraction of the mass of the universe. Another large component of universal matter has been detected by HEAO in the form of gas enveloping clusters of galaxies.

• Precise positions (within 10 arc seconds or better) have been developed for about 140 X-ray sources. The precise positions have enabled ground-based astronomers to locate many of these as faint visible objects. (See detailed HEAO 1 science results on page 9.)

HEAO 1 and HEAO 3 are designated as scanning (or mapping) missions. They rotate slowly end-over-end, with one revolution about every 30 minutes. Each uses a gas thrust reaction control system to maintain proper sky-scanning orientation so that the solar arrays face the Sun at all times to provide electrical power for the satellite.

HEAO 2 is different. It must point to specific stars or points in the sky, so reaction wheels that control torque are installed to provide a precise and highly accurate pointing capability of one arc minute or better for the longer planned mission. HEAO 2 is termed a celestial pointing mission.

HEAO 2 has a designed mission lifetime of one year for pointing at selected X-ray sources. HEAO 3's mission will be six months long.

All three observatories are designed to be placed in low circular orbits, about 455 to 540 kilometers (280 to 335 miles) above Earth. The altitude is far enough above the atmosphere to detect radiation which generally cannot reach the ground.

X-rays and gamma rays are composed of photons, which are particles having energy but no mass, as in light rays. Cosmic rays are composed of particles such as electrons, protons and atomic nuclei which have both mass and energy. An X-ray has thousands of times the energy of ordinary light, and gamma rays have millions of times the energy of visible light.

The high-energy X-rays and gamma rays which the HEAOs study travel through space at the speed of light. They are forms of electromagnetic radiation. Other forms include ultraviolet and infrared radiation.

For many years researchers have studied these forms of radiation and their energy mechanisms and have transformed them into many practical uses, including electrical applications, holography, radio and television, radar and infrared photography.

In high-energy astronomy, interest is in the extreme short-length waves known as X-rays and gamma rays. These rays are produced on Earth by natural radioactive minerals and manmade processes. X-rays and gamma rays on Earth are produced from well-understood physical processes and are used routinely in physics, chemistry, engineering, medical and other scientific fields.

Much is yet to be learned, however, about the way in which X-rays and gamma rays are produced in deep space -- in some cases, with incredible intensity.

It is expected that the radiation data collected by the HEAO observatories, after being reduced and analyzed, will lead to a better understanding of how the extremely high energies are generated in space, how basic elements are formed, how the universe evolved and the extreme physical processes evident within the universe.

Several hypotheses are being pursued in astrophysics and cosmology that need additional experimental evidence which may be obtained by HEAO. These hypotheses are related to radio galaxies, neutron stars, pulsars, quasars, star explosions and supernovae, many of which radiate copiously in the X-ray and gamma ray part of the spectrum. (See glossary, page 17.)

HEAO is managed for NASA's Office of Space Science by the Marshall Space Flight Center, Huntsville, Ala. The Program Manager is Richard E. Halpern and the Program Scientist is Dr. Albert G. Opp, both at NASA Headquarters in Washington, D.C. At the Marshall Center, Dr. Fred A. Speer is the Project Manager. Spacecraft prime contractor is TRW of Redondo Beach, Calif. The X-ray Telescope was designed by Smithsonian Astrophysical Observatory (SAO) and developed by American Science and Engineering (AS&E), both of Cambridge, Mass.

Kennedy Space Center manages the launch operations, including prelaunch checkout, launch and flight through observatory separation in orbit. NASA's Lewis Research Center, Cleveland, Ohio, manages launch vehicle procurement and related activities for the HEAO program.

Control of the in-orbit HEAO observatories is under the direction of the Marshall Center in conjunction with TRW flight control engineers operating from facilities at NASA's Goddard Space Flight Center, Greenbelt, Md.

Cost of the three-mission HEAO program is about $248 million. The cost of HEAO 2 will be approximately $87 million.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

HEAO 1 SCIENCE RESULTS

- Over 130 sources of X-ray radiation have been identified from data analyzed thus far for one ninth of the sky. Many of these were previously undetected. (Many sources have been located with high precision, allowing astronomers to search for visible counterparts.)

- HEAO 1 has returned the highest quality spectal and temporal data yet obtained on neutron stars, and a black hole possibility has been identified near Constellation Scorpius, bringing the total to four. (Others: Cygnus X-1, Circinus X-1, and Hercules X-1.) Also, significant new measurements have been made on neutron stars regarding magnetic fields and dynamics.

- Previously undetected hot thermal plasma has been discovered. The plasma, distributed throughout space, may constitute the bulk of the mass of the universe. This may help answer the question of whether the universe will continue to expand forever or eventually start contracting.

- Extreme variability has been discovered in the X-ray energy band of objects such as quasars (which produce over a billion times the luminosity of the Sun, but may be no larger than the solar system).

- X-ray data have been obtained from the vicinity of two quasars about eight billion light years distant--more than half way to the outer edge of the universe.

- Pronounced soft X-ray emission has been detected for the first time from cataclysmic variable stars (novas, which exhibit extreme flaring, but not supernovas).

- Coronas of normal stars like our Sun have been detected in the X-ray band.

- Strong X-ray emission has been detected, apparently from very hot stellar winds from certain types of stars.

- A massive quantity of gas enveloping two clusters of galaxies has been detected, indicating that sufficient mass may exist in all such systems to convince scientists that the universe is "closed."

- more -

HEAO SPACECRAFT AND OBSERVATORY

The basic subsystems design of the HEAO spacecraft is common for all three missions. The shape, arrangement and objectives of the experiments on the three spacecraft are different for each mission.

The observatories (i.e., spacecraft plus experiments) each weigh about 3,150 kilograms (7,000 pounds), including 1,350 kg (3,000 lb.) of experiments. Overall observatory length is 5.8 meters (19 feet).

The HEAO spacecraft subsystems take advantage of existing hardware designs developed in other spacecraft programs. About 80 per cent of HEAO hardware designs are "off-the-shelf."

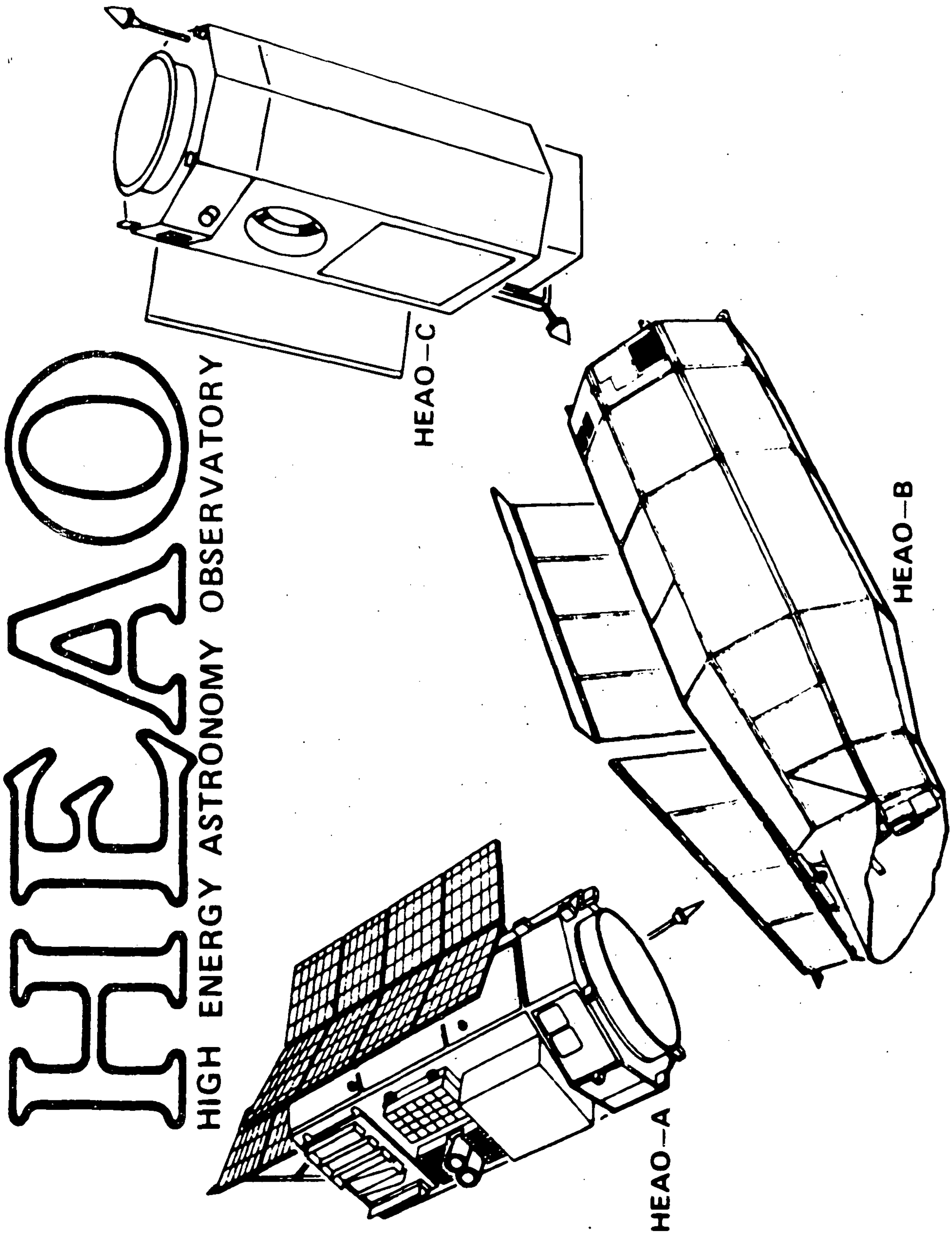
The HEAO 2 experiment module structure is octagonal, and combines simplicity with maximum rigidity and focal length in support of the X-ray telescope.

HEAO 2 mission requirements are met through simple modifications to the HEAO 1 design. For example, the HEAO 2 pointing and stability requirements are met by placing a reaction wheel system in an empty area of the equipment module. The extra electrical power required to drive the wheels is produced by increasing the size of the solar array.

LAUNCH VEHICLE

Contractor for the Atlas booster stage (SLV-3D) is General Dynamics Convair Aerospace Division. The stage-and-one-half Atlas is powered by three engines -- two Rocketdyne YLR-89-NA-7 engines providing 1,646,000 newtons (370,000 lb.) of thrust and one Rocketdyne YLR-105-NA-7 engine with 267,000 N (60,000 lb.) thrust. All three engines operate on liquid oxygen and RP-1 propellants.

General Dynamics is also contractor for the Centaur upper state (D-1A), which is powered by two Pratt and Whitney RL10A-3-3 engines with a total thrust of 133,400 N (30,000 lb). These engines operate on liquid oxygen and liquid hydrogen.


HEAO
HIGH ENERGY ASTRONOMY OBSERVATORY
HEAO—A
HEAO—B
HEAO—C

Physical characteristics of the Atlas SLV-3D stage are:

Length 21 m (70 ft.)

Diameter 3 m (10 ft.)

Dry weight 7,210 kg (15,900 lb.)

Launch weight 130,450 kg (287,600 lb.)

Physical characteristscs of the Centaur D-1A upper stage are:

Length 9 m (30 ft.)

Diameter 3 m (10 ft.)

Dry weight 1,770 kg (3,900 lb.) excluding nose fairing

Launch weight 17,690 kg (39,000 lb.)

Total height of the HEAO Atlas-Centaur space vehicle ready for launch, is 39.9 m (131 ft.) with a launch weight of about 149,600 kg (329,900 lb.) for HEAO-2

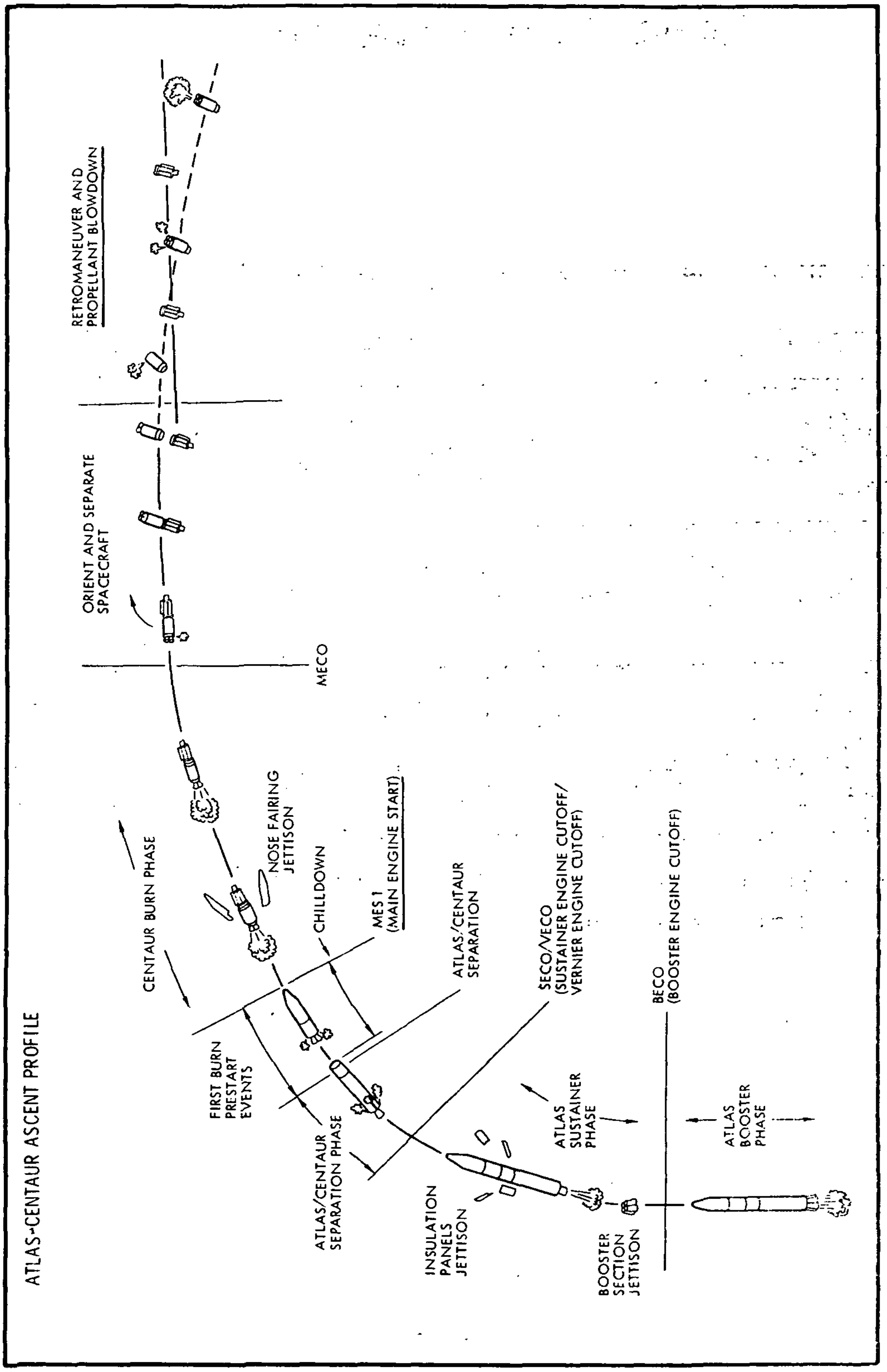
HEAO LAUNCH OPERATIONS

NASA's John F. Kennedy Space Center, Fla., and its Expendable Vehicles Directorate play key roles in the prep-paration and launch of Atlas-Centaur 52 which will carry HEAO-2 into orbit.

The Atlas booster was erected on Pad B at Launch Complex 36, Cape Canaveral Air Force Station, on Sept. 6, and the Centaur upper stage was mated with it on Dept. 8.

The HEAO-2 observatory arrived at KSC aboard a C-5A aircraft during the week of Sept. 11 and was moved into Spacecraft Assembly and Encapsulation Facility 2 for pre-launch processing.

ATLAS-CENTAUR ASCENT PROFILE



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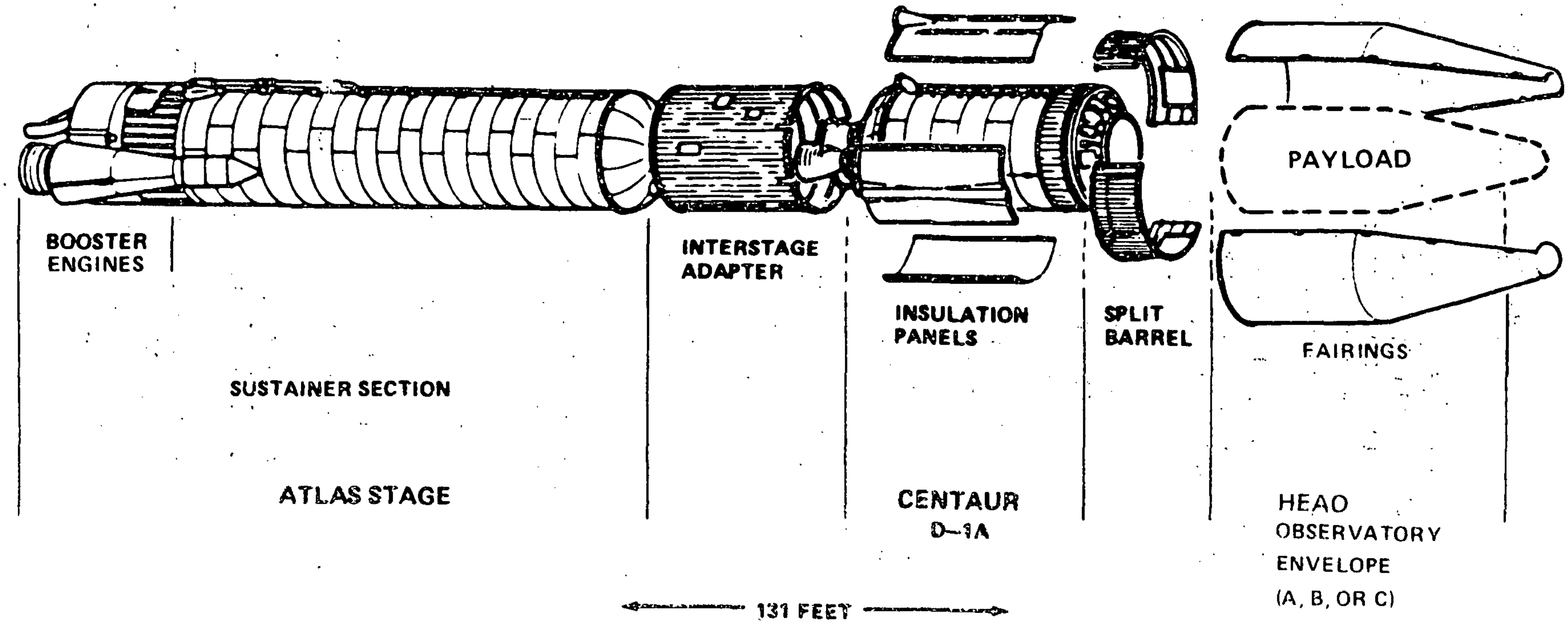
TYPICAL ATLAS-CENTAUR SEQUENCE OF EVENTS

Event	Basis	Approx. Time From Liftoff (Sec.)
Liftoff	2-in. Motion	0
Roll Program	Liftoff + 2 sec.	2-15
BECO	5.3 g	140
Booster Package Jettison	BECO + 3.1 sec.	145
Jettison Insulation Panels	BECO + 45 sec.	187
SECO	Prop. Depletion	247
Separation	SECO + 1.9 sec.	249
MES 1	SECO + 11.5 sec.	259
Jettison Nose Fairing	MES 1 + 12 sec.	270
MECO 1	Final Orbit (Guid.)	700
Separation	MECO 1 + 660 sec.	1360

ATLAS/CENTAUR D-1A

HEAO SPACE VEHICLE FOR A, B, & C OBSERVATORIES



HEAO MISSION OPERATIONS

Control of the in-orbit HEAO observatories is directed by Marshall flight control engineers at the Goddard center. Flight control operations are performed by TRW under the direction of the Marshall flight director and supported by experimenters associated with each HEAO mission.

The Marshall center directs the mission planning and establishes support requirements to be met by the world-wide Spaceflight Tracking and Data Network (STDN), the Operations Control Center and Data Processing Center.

Goddard provides and operates these network and mission operations support facilities required by Marshall to control and operate the observatories.

These existing NASA facilities are prepared and configured as necessary to support the HEAO missions.

The large amounts of data taken by each of the HEAO observatories are reduced and analyzed by the principal investigators, co-investigators and other scientists from the United States representing various industries, universities and government agencies. They make known their findings in various reports, papers and publications.

HEAO 2 MISSION DESCRIPTION

HEAO 2 will examine specific X-ray sources from an orbit inclined 23.5 degrees to the equator and at a height of 535 km (330 miles.)

The observatory will be placed in orbit by an Atlas-Centaur D-1A launch vehicle. The ascent profile, the same as that for HEAO 1, is shown in the diagram on page 12.

After insertion into orbit, the HEAO goes through three principal modes of operation:

1. Activation. This mode includes solar array deployment, removal of separation transients, Sun acquisition, and activation of thermal control heaters and standby heaters, if necessary. Then subsystems are activated, calibrated and checked out. During this procedure, the +Z axis is held within a seven degree half-cone angle of the Sun line.

2. Experiment checkout. Experiments are activated and checked out after observatory subsystems are operating properly. The initial data from each experiment will be obtained by an on-off cycle so that experiment operation can be evaluated before turn-on for routine operation.

3. Celestial point. The routine point mode, initiated by ground command, will be continuous for 12 months. The alignment of the +Z axis toward the Sun will be maintained within 15 degrees half-cone angle of a chosen reference. Up to two targets per orbit are available by design.

The observatory will be controlled in orbit by the HEAO Operations Control Center (HEAO-OCC) at Goddard. Observatory data stored in the on-board tape recorder will be transmitted to tracking sites at a rate of 128 kbps. Data from six orbits per day will be relayed to the HEAO-OCC at a reduced rate and will be used for evaluation by principal investigators.

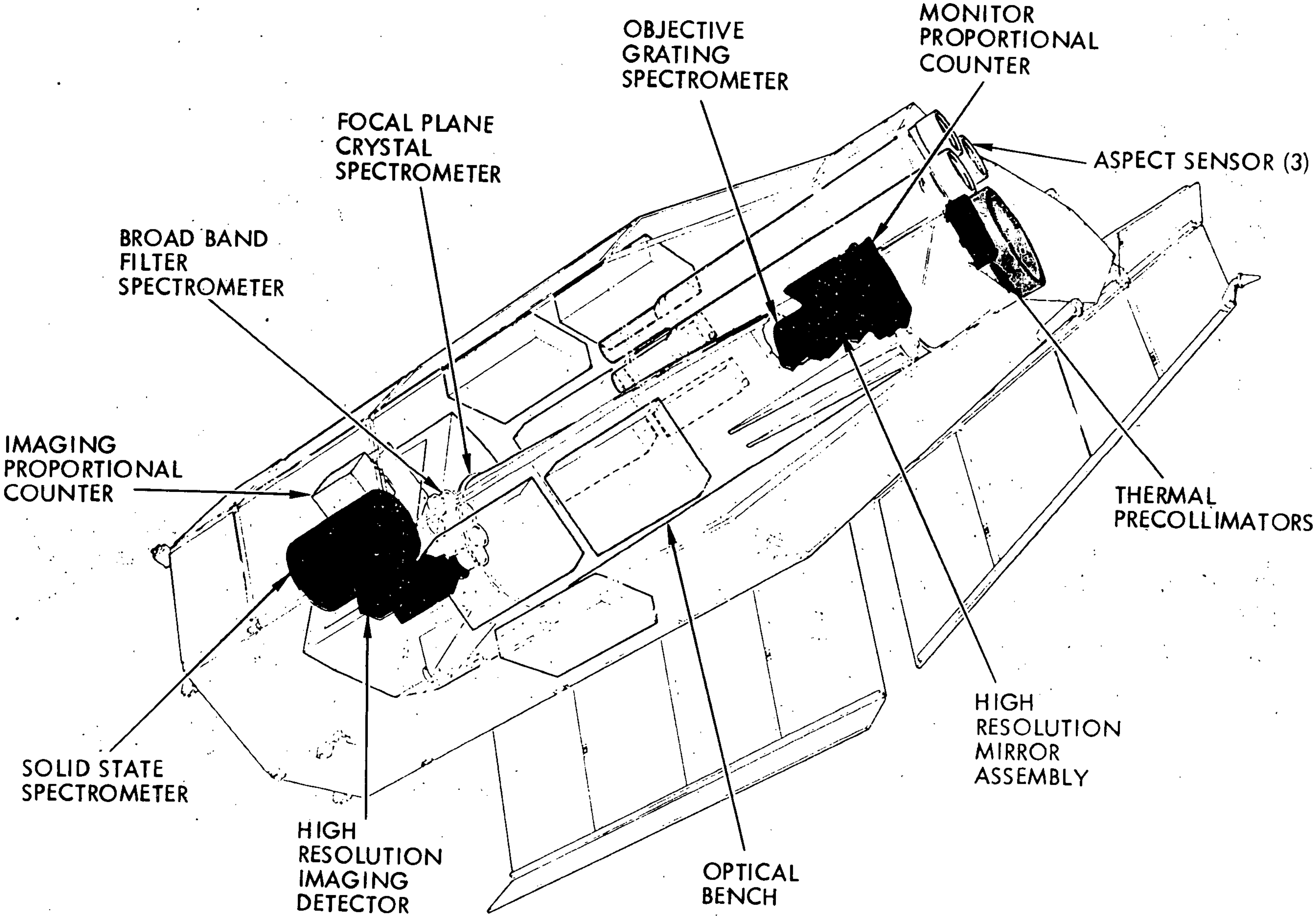
Tracking stations permit relay of data to the HEAO-OCC at 9.6 to 56 kbps.

HEAO 2 EXPERIMENTS

A consortium of experimenters has been organized involving scientists from five organizations, including the Smithsonian Astrophysical Observatory (SAO), Massachusetts Institute of Technology (MIT), American Science and Engineering (AS&E), Goddard Space Flight Center (GSFC) and Columbia Astrophysics Laboratory (CAL). The principal investigator and scientific director of the consortium is Dr. Riccardo Giacconi of SAO.

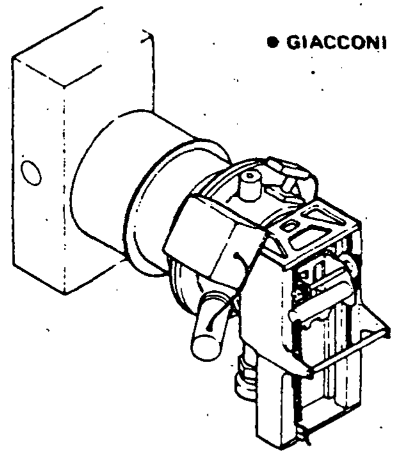
The grazing-incidence X-ray telescope on HEAO 2 will produce images of X-ray sources which are then analyzed by interchangeable instruments at the focal plane of the telescope. In addition to the instruments at the focal plane, there is one complementary instrument which directly views the areas out in space along the same direction as the telescope.

HEAO-B EXPERIMENTS

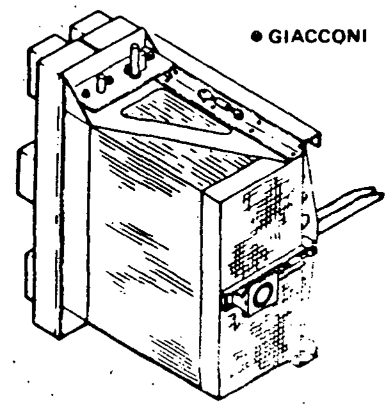


HEAO-B EXPERIMENTS

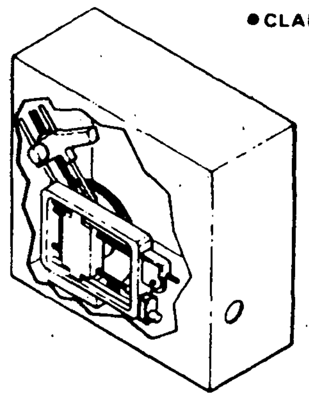
B-2 HIGH RE OLUTION IMAGER



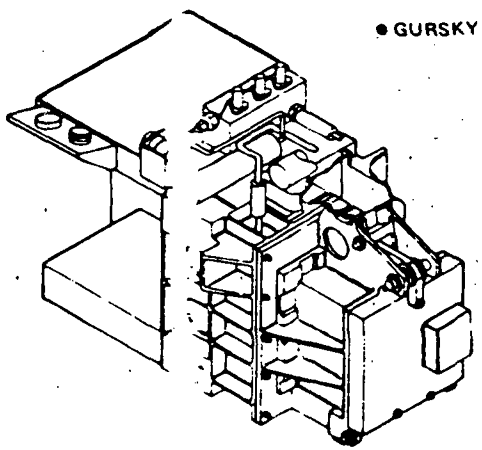
B-1 MONITOR
PROPORTIONAL COUNTER



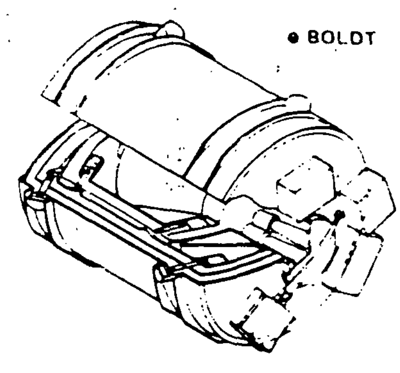
B-3 FOCAL PLANE
CRYSTAL SPECTROMETER



B-4 IMAGINC PROPORTIONAL
CO NTER



B-5 SOLID STATE
SPECTROMETER



The science objectives of the HEAO 2 telescope experiment are:

- Determine structural details of extended wide X-ray sources and identify with optical objectives by studying X-ray images.

- Perform spectroscopy measurements to determine X-ray emission mechanism and spectral features.

- Analyze temporal behavior of X-ray sources on a scale of one microsecond to one year.

HEAO 2 telescope instruments are:

B-1: Monitor Proportional Counter. Principal Investigator is Dr. Giacconi. Hardware was developed by AS&E under NASA contracts.

The Monitor Proportional Counter is mounted near one end of the observatory and operates independently of the telescope. It observes the same region of the sky as the telescope but over a much wider energy range (0.2 to 20 KeV). It provides a means of correlating observations made by all the focal plane instruments.

B-2: High Resolution Imager Instrument. Principal Investigator is Dr. Giacconi. Hardware was developed by AS&E under NASA contracts.

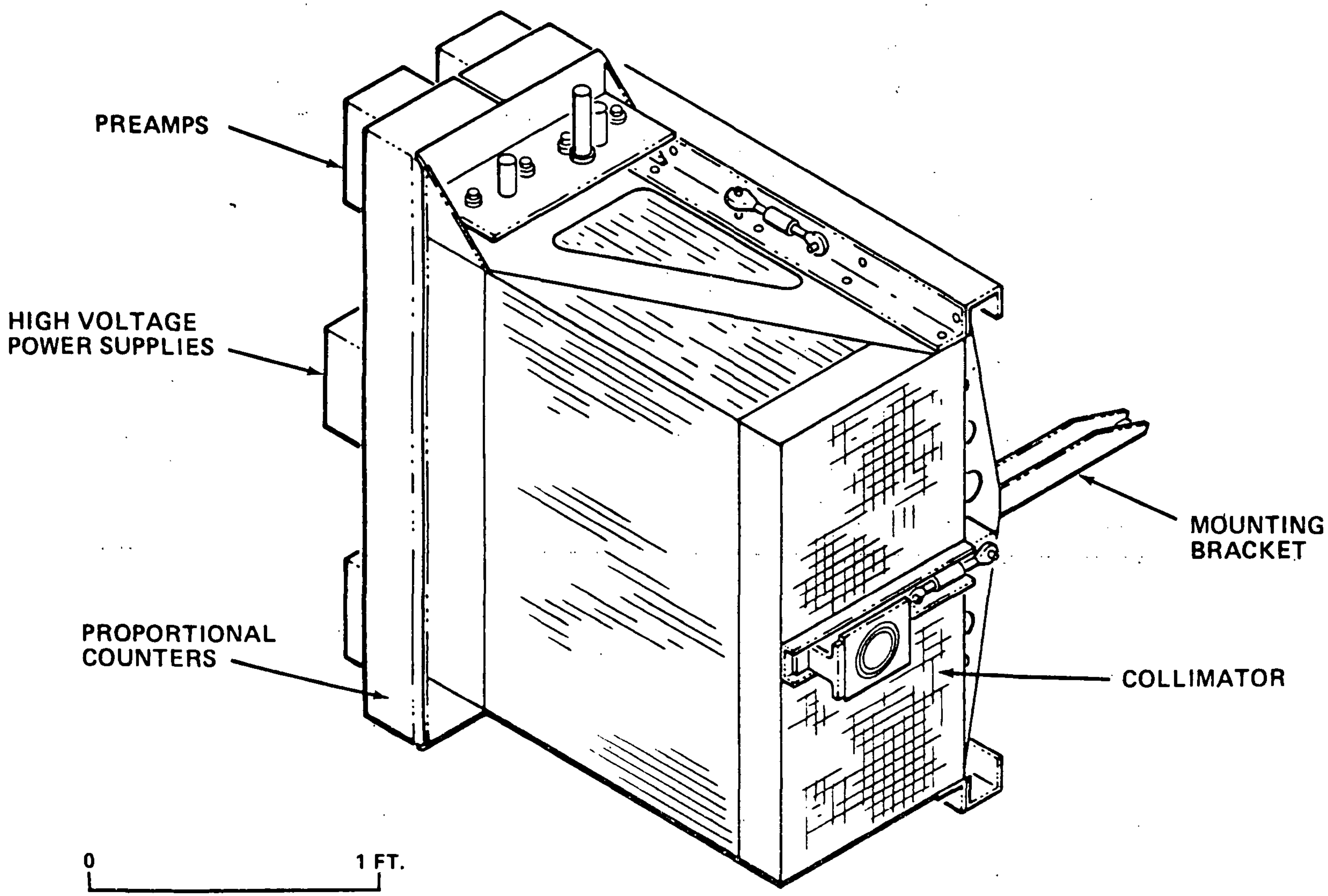
The High Resolution Imager Instrument (like the Imaging Proportional Counter described below under B-4) is designed to take advantage of the imaging capability of the X-ray telescope. The High Resolution Imager uses advanced solid state techniques to record the images with a resolution of 1 - 2 arc seconds--the limit of the resoltuion capability of the telescope itself.

B-3: Focal Plane Crystal Spectrometer. Principal Scientist is Dr. George Clark of MIT. Hardware was developed by MIT under NASA contract.

The Focal Plane Crystal Spectrometer makes use of the X-ray deffraction properties of certain crystals to study in detail the X-ray spectra produced by celestial targets. The detector for the diffracted rays is a small proportional counter. This instrument can detect individual X-ray emission lines to help unravel questions about the chemical composition and other properties of the X-ray targets.

HEAO B-1 EXPERIMENT
MONITOR PROPORTIONAL COUNTER

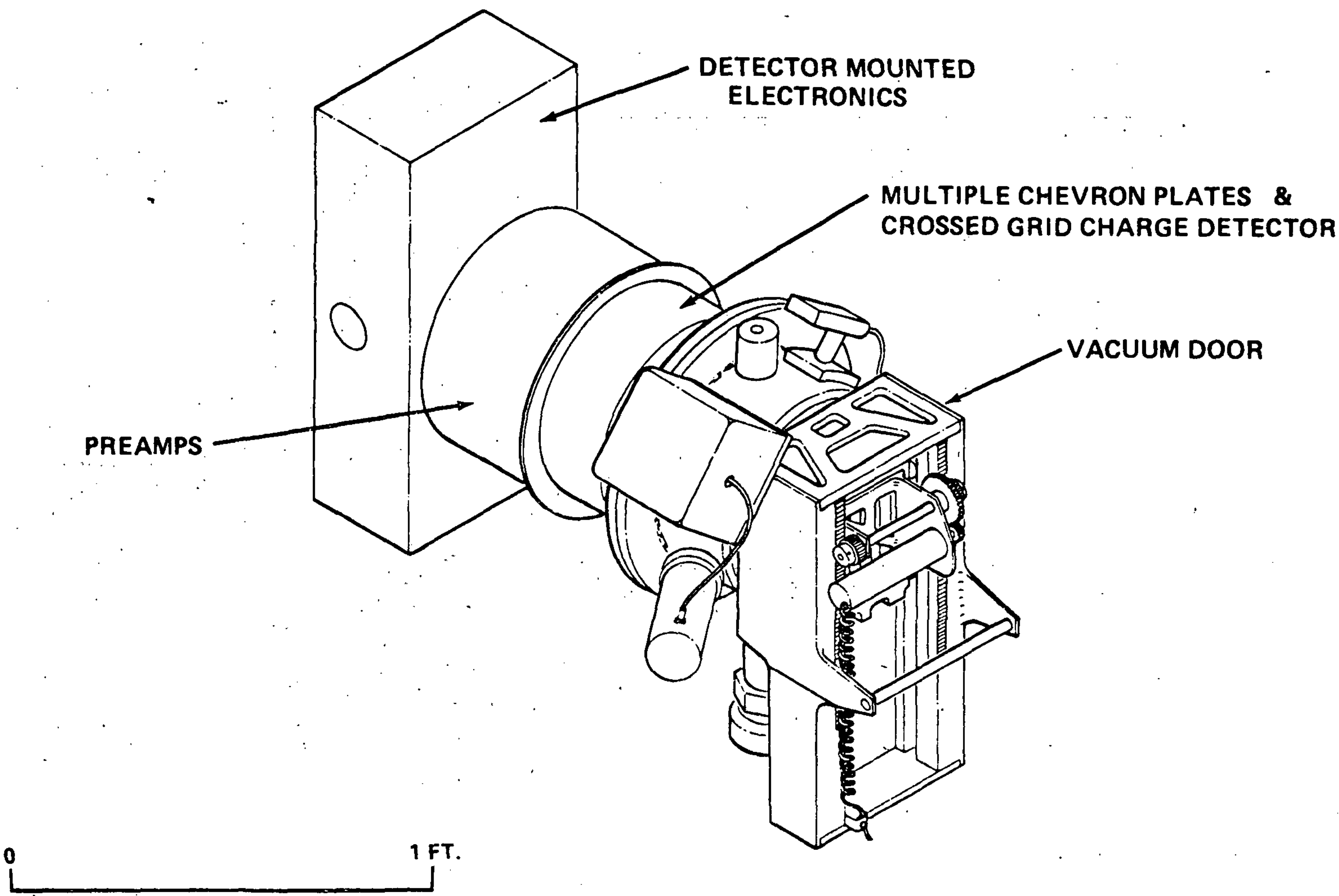
GIACCONI



HEAO B-2 EXPERIMENT

HIGH RESOLUTION IMAGER

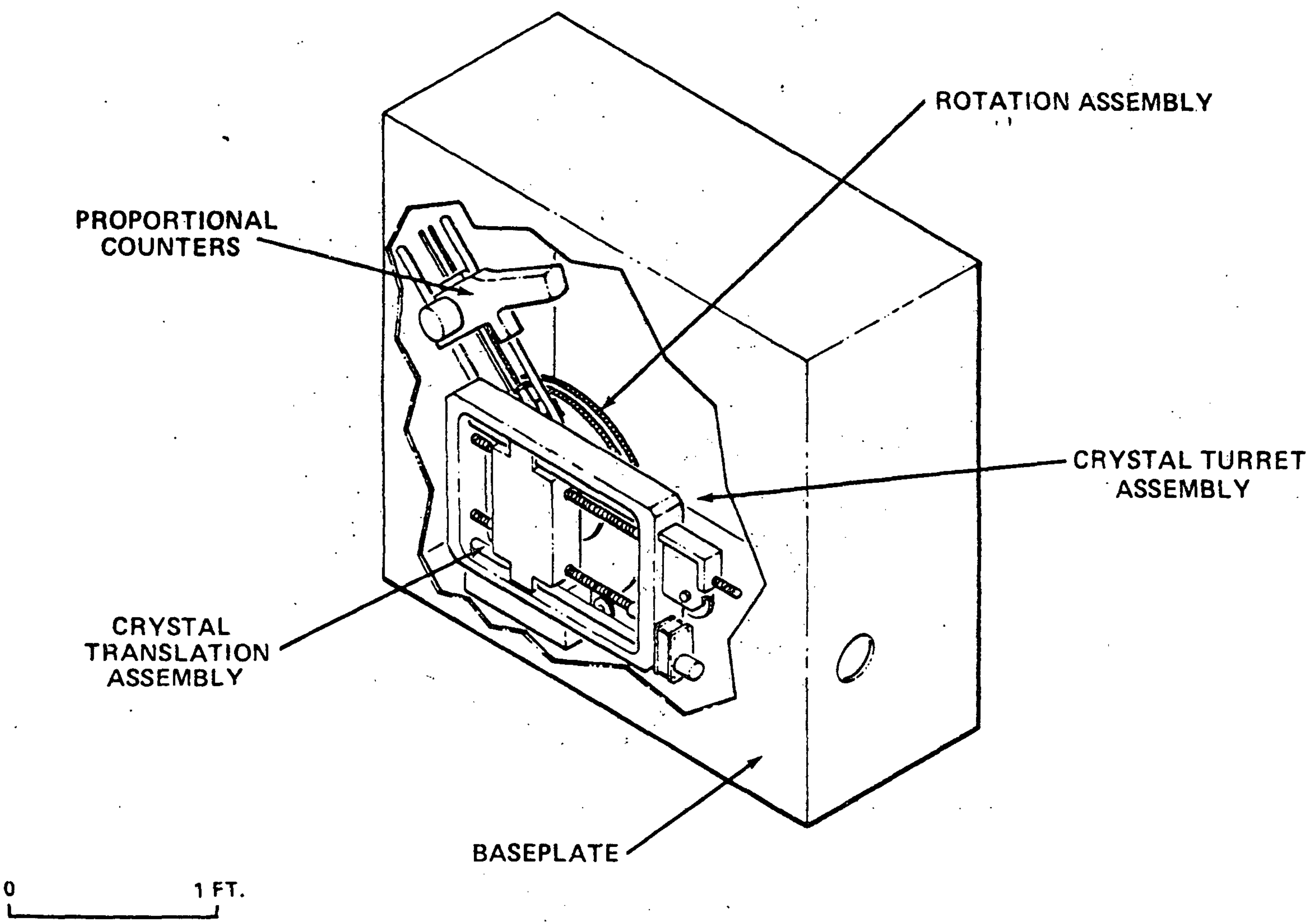
GIACCONI



HEAO B-3 EXPERIMENT

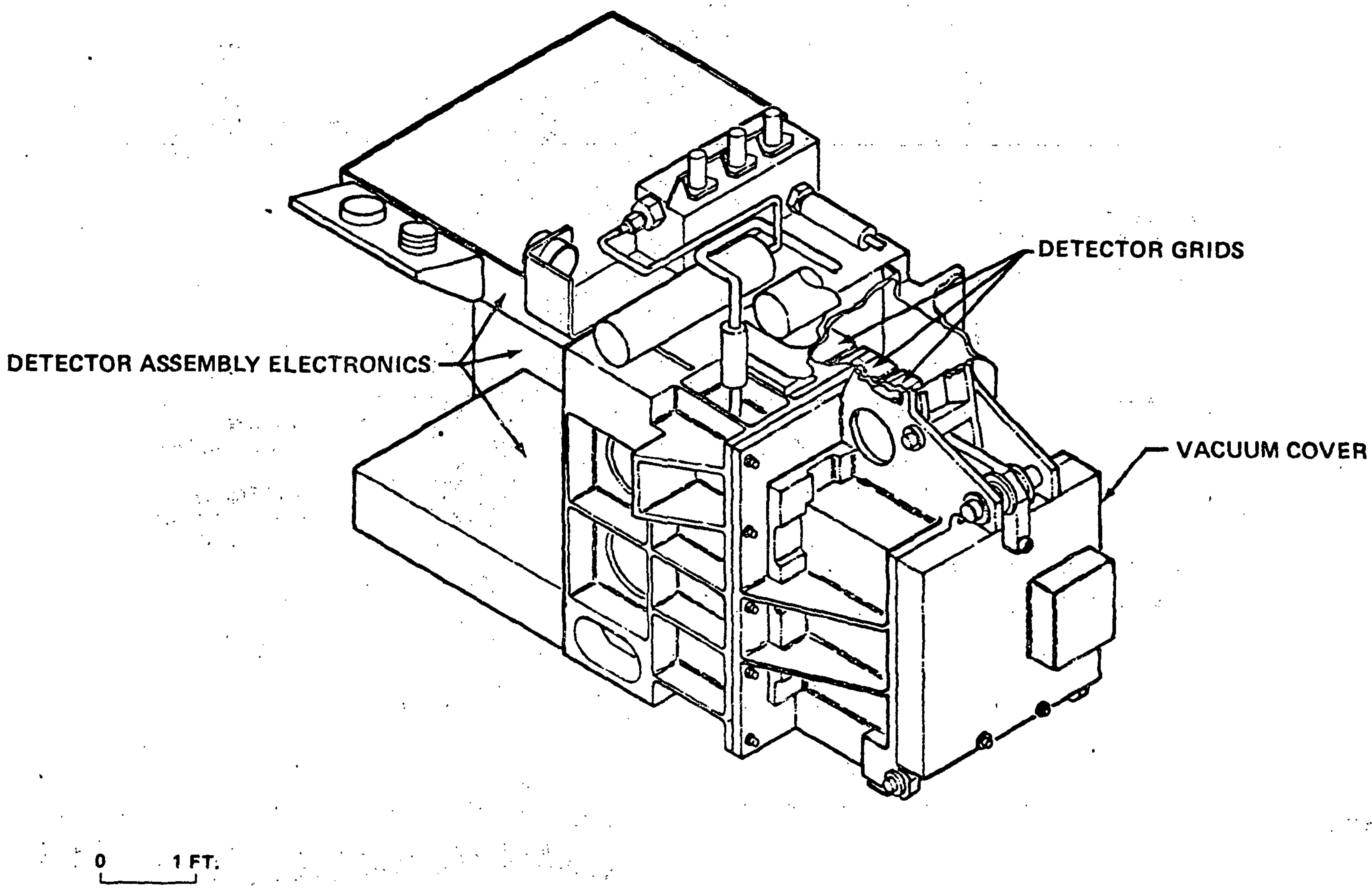
FOCAL PLANE CRYSTAL SPECTROMETER

CLARK



HEAO B-4 EXPERIMENT
IMAGING PROPORTIONAL COUNTER

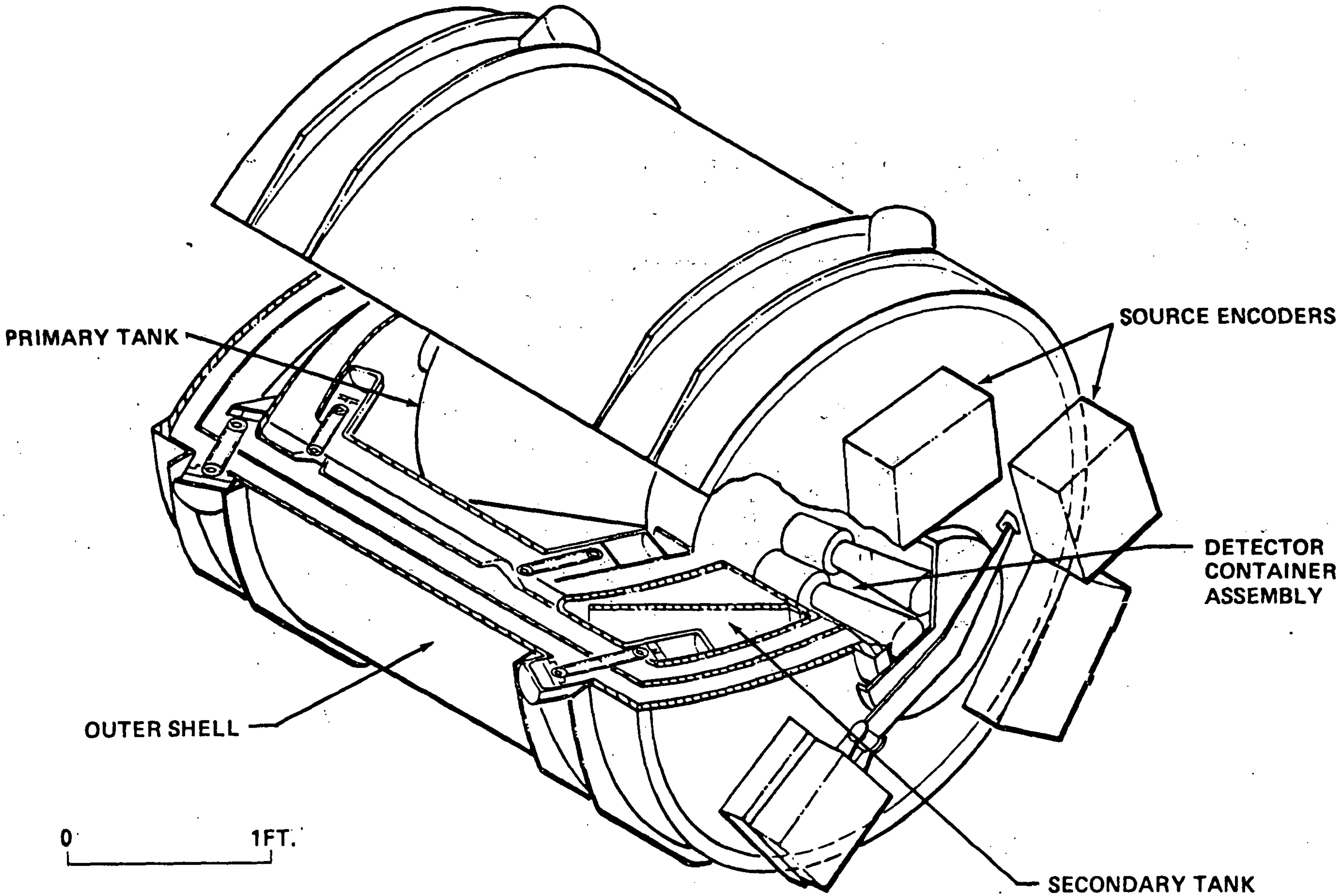
GURSKY



HEAO B-5 EXPERIMENT

SOLID STATE SPECTROMETER

BOLDT



To cover the full range of the telescope, six different crystals (mounted on a turret) are used.

B-4: Imaging Proportional Counter. Principal Scientist is Dr. Herbert Gursky of SAO. Hardware was developed by AS&E under NASA contract.

The Imaging Proportional Counter uses the same basic techniques as most of the X-ray detectors on HEAO 1, but the counter is electronically subdivided into very small regions so that each registers a small part of the X-ray image. The result is an image with a resolution of about one arc minute. What the Imaging Proportional Counter lacks in imaging resolution, it makes up in greater field of view than the High Resolution Imager.

B-5: Solid State Spectrometer. Principal Scientist is Dr. Elihu Boldt of GSFC. Hardware was developed by GSFC under an inter-center agreement.

The Solid State Spectrometer must be cryogenically cooled with solid methane and ammonia for its silicon-germanium crystal to function properly. Its advantage is that it can observe the entire spectrum at once, measuring the energy (and therefore wave-length) of each photon which strikes the crystal, whereas the Focal Plane Crystal Spectrometer can only examine a small band of energies at any one setting of the crystal turret. The two spectrometers complement each other in sensitivity and energy resolution.

Principal Scientist Dr. Robert Novick of CAL, is providing scientific support and performing data analysis as a member of the consortium group under NASA contract.

AS&E physically and functionally integrated the various instruments into a telescope experiment. The X-ray telescope was calibrated in the new X-ray Test Calibration Facility at the Marshall center. The assembled telescope was delivered from Marshall to TRW for integration with the spacecraft module.

GLOSSARY

Pulsars and Neutron Stars

Discovered in 1967, pulsars are stars which emit radio signals in extremely precise pulses. The bulk of available evidence suggests that pulsars may be fast-spinning neutron stars. These are compact bodies of densely packed neutrons (atomic particles having no electric charge), believed to form when a large star burns up much of its fuel and collapses. Containing the mass of a star in a sphere 16 km (10 mi.) in diameter, they are so closely packed that a spoonful of material from the center would weigh a billion tons.

Black Holes

These are believed to be the final stages in the collapse of a dying star. The star's material is so densely packed -- even more so than a neutron star -- and its gravitational force so great that even light waves are unable to escape. Black holes have been hypothesized but conclusive observations have not yet been possible.

Quasars

Astronomers are still baffled by the nature of quasars, but many believe that among observable objects they are the most remote in the universe. They look like stars when viewed through an optical telescope but emit more energy than the most powerful galaxies known. According to calculations, if they are as distant as many astronomers think they are, the total energy emitted by a quasar in one second would supply all of Earth's electrical energy needs for a billion years.

Radio Galaxies

Located on the fringes of visibility, radio galaxies emit radio waves millions of times more powerful than the emissions of a normal spiral galaxy. No one knows what these peculiar galaxies are. Several of them broadcast with such power that a sizable fraction of the nuclear energy locked up in their matter must be going completely into the production of radio waves.

Supernovae

Supernovae are large stars at their lives' ends whose final collapses are cataclysmic events that generate violent explosions, blowing the surface layers of the stars out into space. There, the materials of the exploded stars mix with other material of the universe (primarily hydrogen). Later in the history of the galaxy, other stars are formed out of this mixture. The Sun is one of these stars; it contains debris of countless others that exploded before the Sun was born.

There is strong evidence that supernovae (exploding stars) and pulsars are X-ray sources at some time in their history and that X-rays have been observed from radio galaxies and quasars.

THE HEAO 2 TEAM

NASA Headquarters

Dr. Noel W. Hinners	Associate Administrator for Space Science
Andrew J. Stofan	Deputy Associate Administrator for Space Science
Dr. Adrienne Timothy	Assistant Associate Administrator for Space Science
T. Bland Norris	Director, Astrophysics Programs
Richard E. Halpern	Manager, High Energy Astrophysics Payloads
John F. Yardley	Associate Administrator for Space Transportation Systems
Joseph B. Mahon	Director, Expendable Launch Vehicles
F. R. Schmidt	Manager, Atlas Centaur Launch Vehicle
Dr. William Schneider	Associate Administrator for Space Tracking and Data Systems

Marshall Space Flight Center

Dr. William R. Lucas	Director
Dr. Fred A. Speer	Manager, HEAO Project
Fred S. Wojtalik	Chief Engineer, HEAO Project
Charles H. Meyers	Manager, Spacecraft Office
Alex Madyda	HEAO 2 Mission Manager

<u>Goddard Space Flight Center</u>

Dr. Robert S. Cooper	Director
Dr. Steve Holt	Project Scientist, HEAO 2
Dr. Elihu A. Boldt	Principal Scientist, Solid State Spectrometer Experiment (B-4)
Richard S. Costa	Mission Operations Systems Manager
Tecwyn Roberts	Director of Networks, Tracking and Data Acquisition
Albert G. Ferris	Director, Mission and Data Operations

<u>Kennedy Space Center</u>

Lee R. Scherer	Director
Gerald D. Griffin	Deputy Director
Dr. Walter J. Kapryan	Director, Launch Operations
George F. Page	Launch Director, Expendable Vehicles
John Gossett	Chief, Centaur Operation Division
Laurence F.Kruse	Spacecraft Coordinator

<u>Lewis Research Center</u>

Dr. John McCarthy	Director
Larry Ross	Director, Launch Vehicles
Edwin T. Muckley	HEAO Project Engineer

Smithsonian Astrophysical Observatory

Dr. Herbert Gursky	Principal Scientist, Imaging Proportional Counter (B-4)
Dr. Riccardo Giacconi	Principal Investigator, Monitor Proportional Counter (B-1) and High Resolution Imager (B-2)

Massachusetts Institute of Technology

Dr. George Clark	Principal Scientist, Focal Plane Crystal Spectrometer (B-3)

Columbia University

Dr. Robert Novick	Consortium member

CONTRACTORS

TRW Redondo Beach, Calif.	Spacecraft design and manufacture, observatory integration
American Science and Engineering Cambridge, Mass.	Design and manufacture, X-ray telescope system
General Dynamics Convair San Diego, Calif.	Launch vehicle manufacture

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