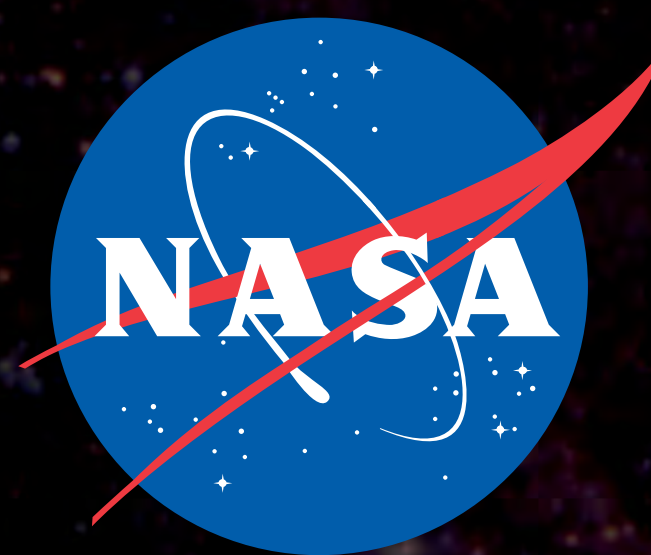


National Aeronautics and Space Administration

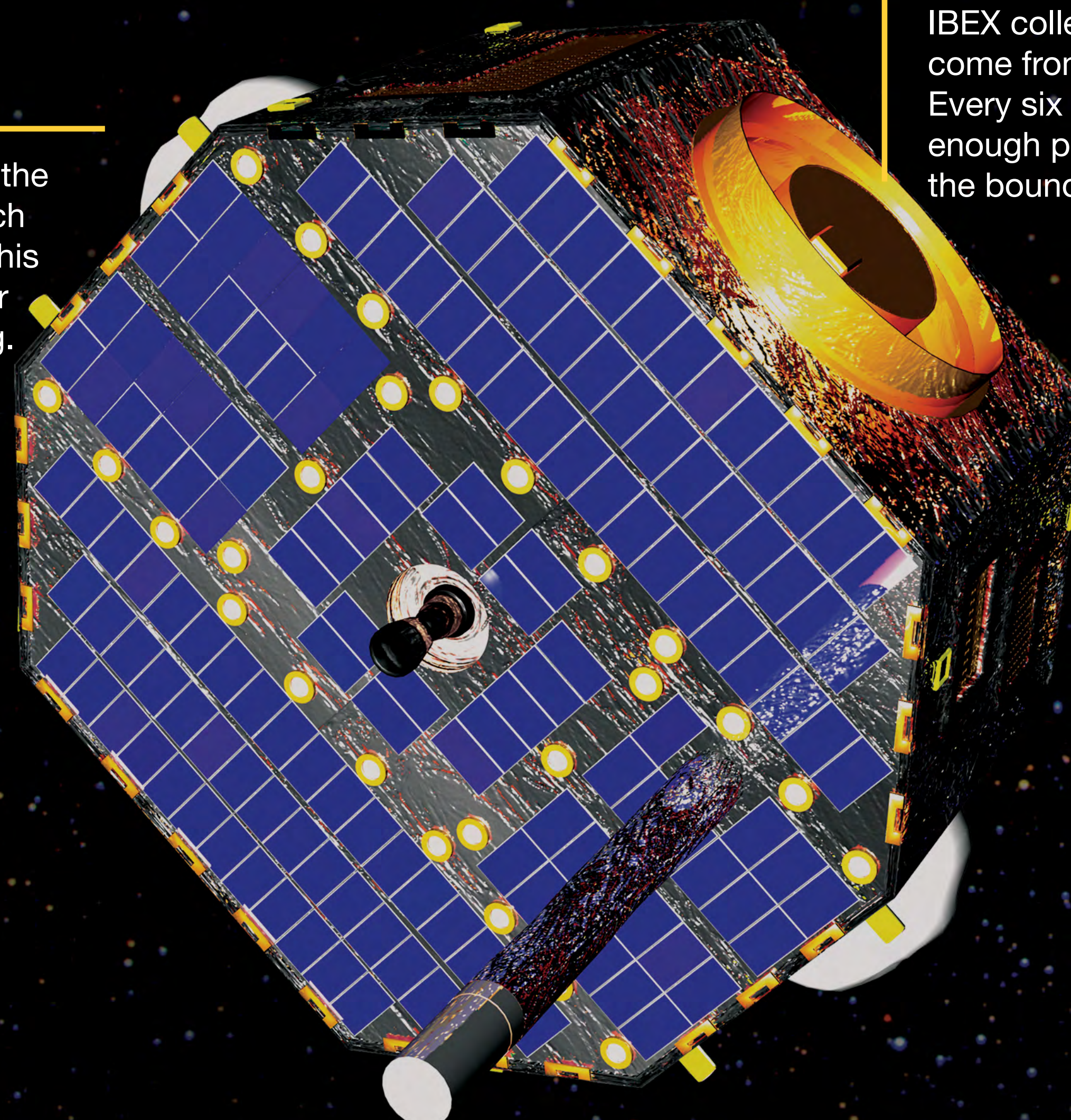


# IBEX: Interstellar Boundary Explorer

The IBEX spacecraft orbits the Earth and collects data to map the solar system's boundary for the first time. Maps created by IBEX teach us about the shape and nature of the heliosphere, the invisible bubble that surrounds the solar system.



IBEX's orbital path takes it 5/6 of the distance to the Moon's orbit. Each orbit takes 8 days. Even though this orbit is high, it is still incredibly far from the boundary it is measuring.



IBEX collects data about particles that come from the solar system's boundary. Every six months, the sensors detect enough particles to create a picture of the boundary across the entire sky.

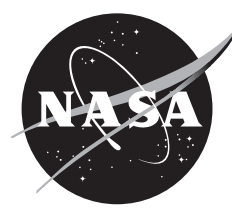
IBEX communicates by using antennae on its surface to send radio signals to a network of receivers on Earth.

*Exploring The Edge Of Our Solar System*

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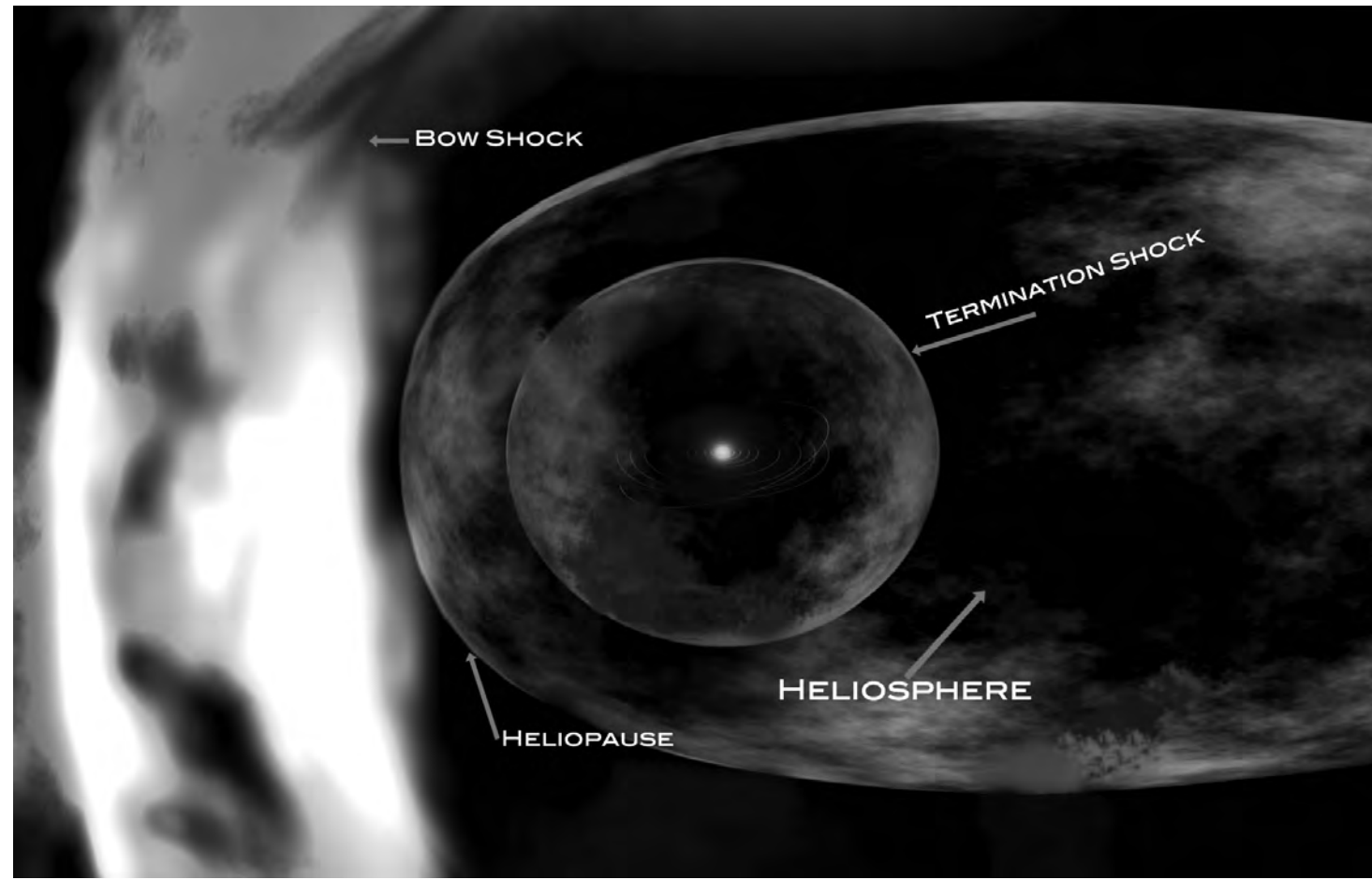




## What is IBEX?

IBEX is a NASA-funded Small Explorer satellite mission to orbit Earth and map the boundary of the Solar System. The acronym **IBEX** stands for **I**nterstellar **B**oundary **E**xplorer.

The boundary of our Solar System is created by the interaction between particles from the Sun that are streaming outward, called the **solar wind**, and material between the stars, called the **interstellar medium (ISM)**. The solar wind streams out into space and carves out a protective bubble, called the **heliosphere**, in the ISM around our Solar System. The outer edge of the boundary of the heliosphere is called the **heliopause**, and the inner edge is called the **termination shock**. The interactions between the solar wind particles and ISM particles create **energetic neutral atoms (ENAs)**, which are particles with no charge that move very fast. IBEX collects some of the ENAs which stream inward toward Earth. The mass, location, direction of origin, and energy of these particles provide information about the Solar System's boundary.

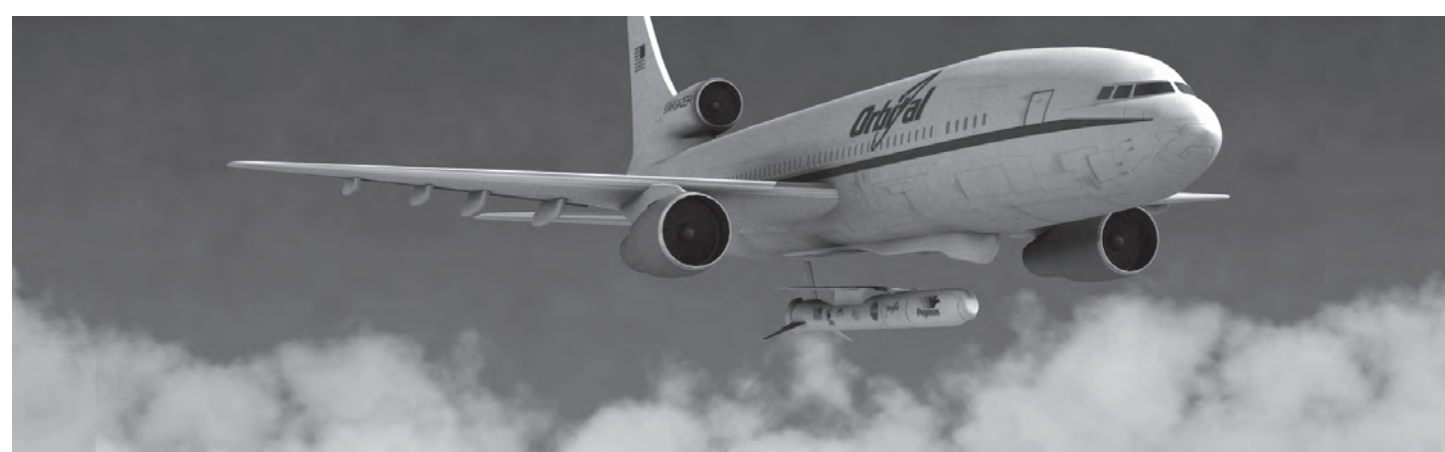


An artist's rendition of the parts of the heliosphere (not to scale) Credit: NASA/Walt Feimer.

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## How does IBEX get into space? Where does IBEX orbit?



Artist's rendition of the L1011 aircraft and Pegasus rocket. Credit: The Adler Planetarium.

IBEX uses a Pegasus rocket to launch into space. This is an inexpensive launch option, especially for smaller spacecraft.

IBEX begins its ride during a launch from Kwajalein Island, Marshall Islands in the middle of the Pacific Ocean. An L-1011 airplane takes the Pegasus rocket and the attached IBEX spacecraft to a high altitude. Then, the Pegasus fires its own rockets to propel it and IBEX into space.

The satellite has its own small rocket engine that will allow it to climb into an orbit that takes it 5/6 of the distance to the Moon's orbit, or around 200,000 miles (325,000 km) away. Even though this orbit is high, it is still very far from the Solar System boundary that it is measuring. The distance to the near edge of the heliosphere is around 9 billion miles (14 billion km) from the Earth, or about 90 times the distance between the Earth and the Sun.

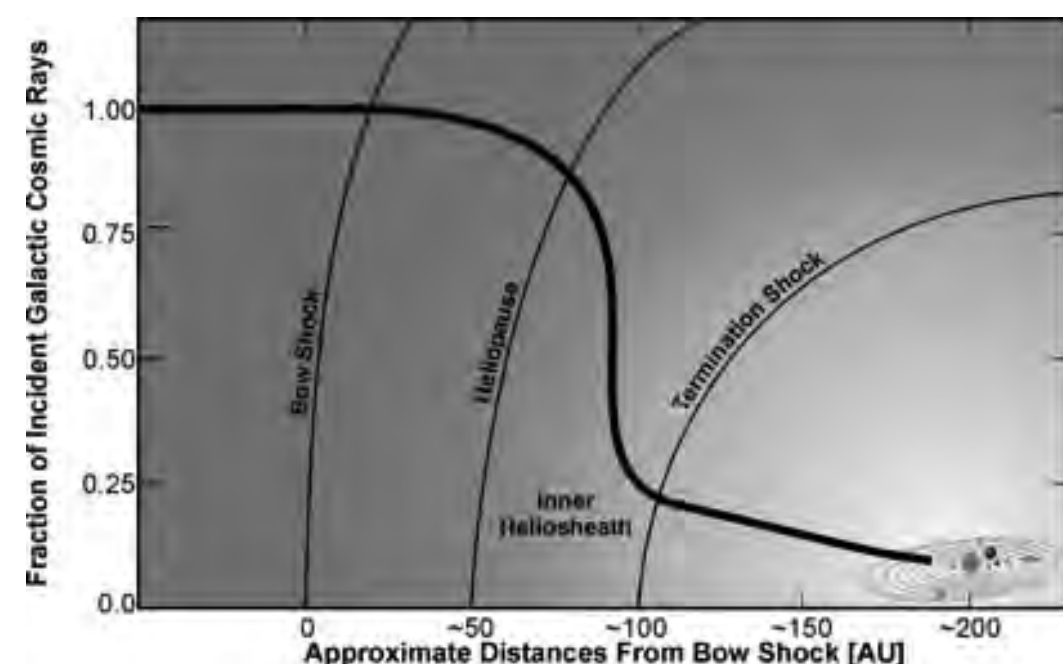
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## Why is IBEX's mission important?

IBEX will be the first spacecraft to map the entire region of the Solar System boundary. Mapping the current state of the outer edge of the heliosphere, called the **heliopause**, will help scientists to determine what this important protective boundary is like. The heliopause and the heliosheath are regions that protect our Solar System from incoming cosmic rays. Cosmic rays are energetic particles that are often made when a star explodes; other cosmic rays come from the Sun or from as far away as other galaxies. If cosmic rays impact something, they can do damage to atoms and molecules. If the Solar System did not have this boundary, then there would be around 4 times more high-energy cosmic rays that would enter our Solar System.

Life on Earth benefits from two other layers that protect us from cosmic rays – our planet's magnetic field, or **magnetosphere**, and atmosphere. If there were a dramatic increase in the number of cosmic rays entering the Solar System, such as from a nearby supernova, more cosmic rays might then reach the Earth's surface. Damage to the Earth's ozone layer could occur, and cosmic rays could cause damage and mutation to DNA. Additionally, when humankind travels to the Moon again or to other locations in our Solar System, astronauts would be outside of the Earth's atmosphere and magnetosphere, so knowing more about the protective abilities of the heliopause will help us plan for future long-term space travel that is safer for humans.



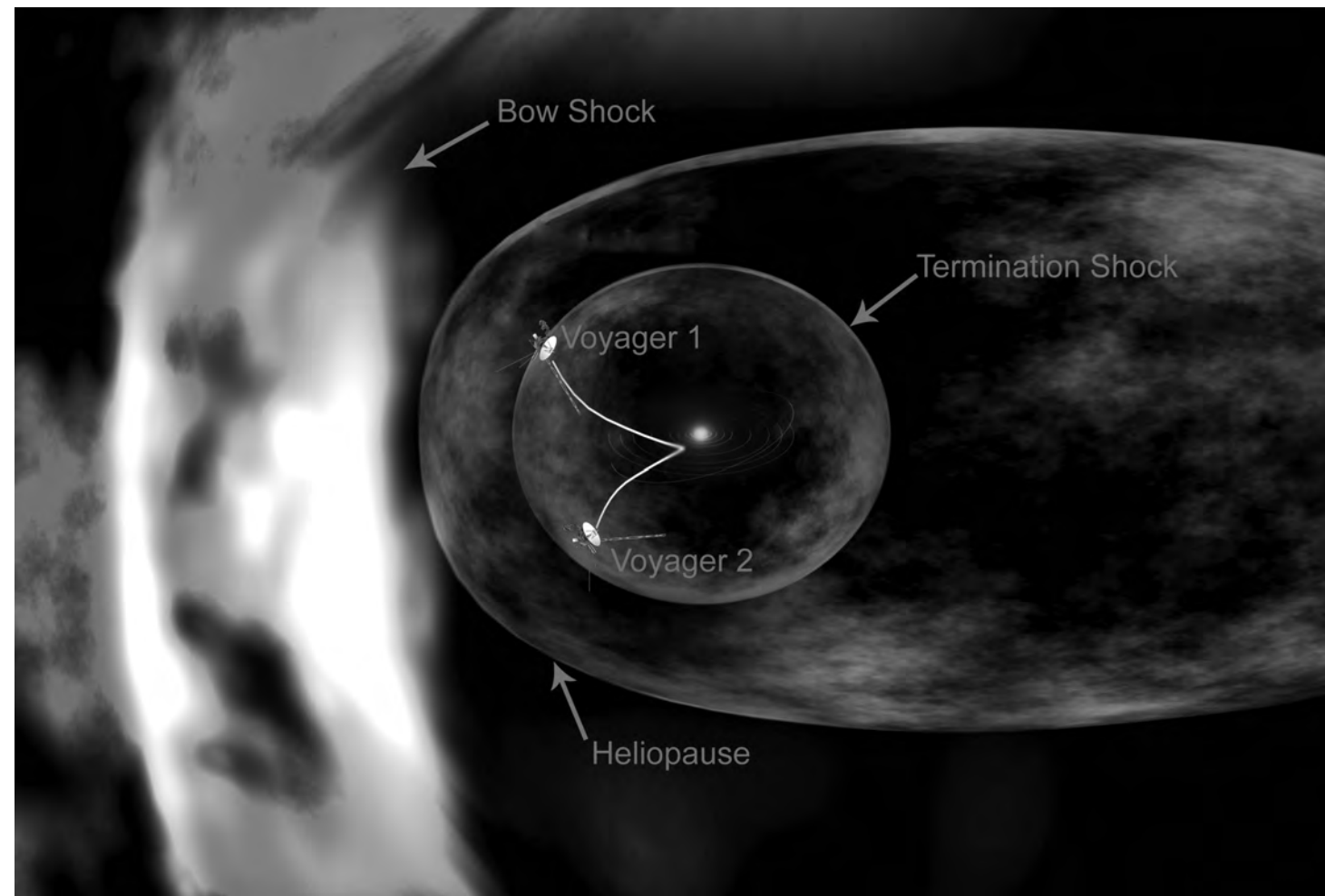
This graph shows a representation of the percentage of cosmic rays that are blocked by the boundary of our Solar System in terms of distance from the boundary in astronomical units (1 AU = 93 million miles). Only about 1 in 4 cosmic rays reaches the area of the planets. Credit: IBEX Science Team.

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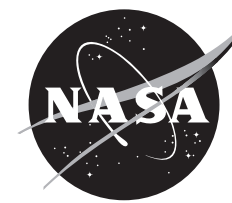
## What came before IBEX?

In the late 1970s and 1980s, the Voyager spacecraft expanded our knowledge of the outer Solar System. Voyagers 1 and 2 both explored the planets Jupiter and Saturn, and Voyager 2 explored Uranus and Neptune. After their planetary observations, both spacecraft continued outward in different directions. The Voyagers were only supposed to last a few years, but they have continued to operate for over 30 years, well past their designed lifetimes. Today, both Voyagers are taking direct measurements of the magnetic field strength and the speed of the solar wind plasma in the boundary region. These data will be combined with IBEX's data, allowing scientists to create a more complete model of the boundary of our Solar System.

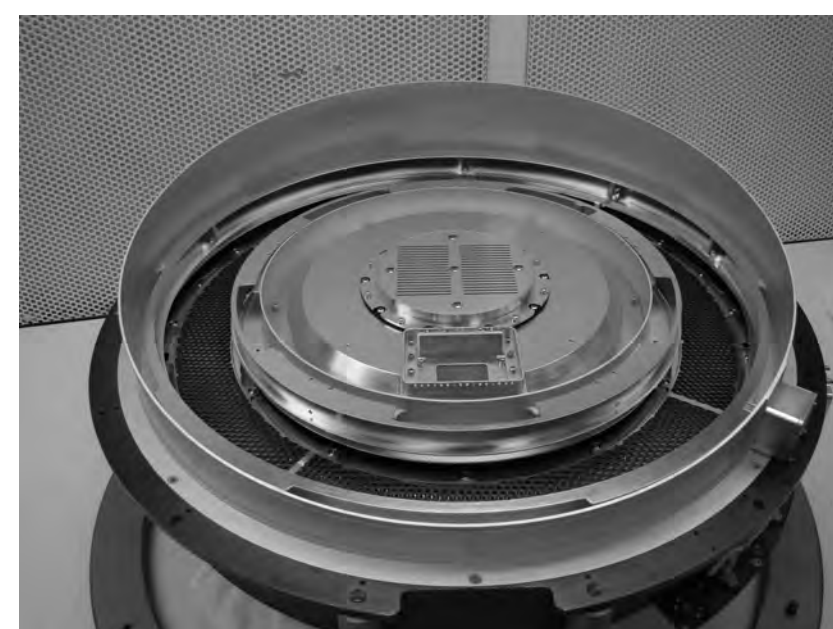


An artist's rendition of the parts of the heliosphere, as well as the directions of travel & approximate locations of the Voyager spacecraft. (not to scale) Credit: NASA/Walt Feimer.

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## How does IBEX collect data?



The IBEX-Hi sensor, one of two sensors on the IBEX spacecraft (IBEX-Hi and IBEX-Lo). Credit: IBEX Science Team.

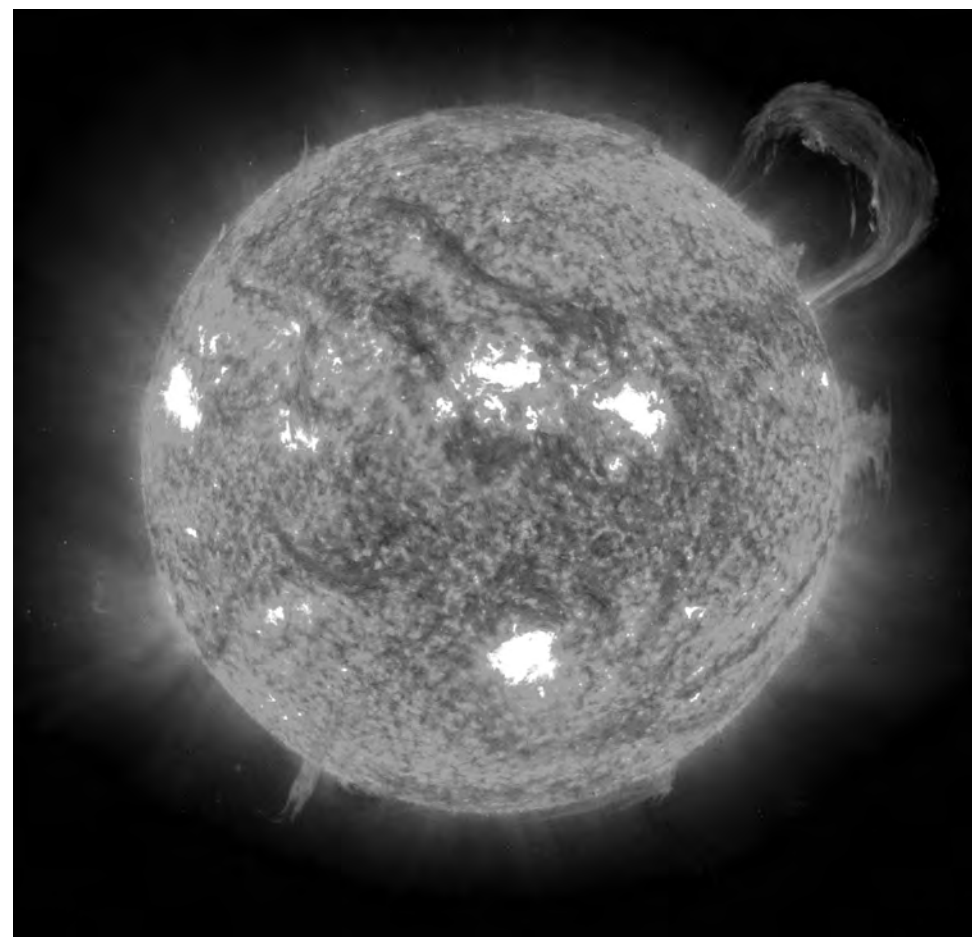
Some of the ENAs happen to get knocked in a straight line in just the right way so that they travel in through the Solar System toward the IBEX spacecraft. This is how the scientists can map the boundary – they know the direction of travel of each particle since they did not change direction between the heliopause and the IBEX spacecraft. IBEX's sensors detect between one particle per hour and a few per second.

To make sure that only ENAs enter IBEX's collectors, ions are deflected before they even enter the collectors. The sensors sort the particles and keep track of the direction of travel of all of the particles, the time they entered the sensor, the mass of the particles, and the amount of energy each particle has. Though IBEX cannot determine the distance the particles have traveled, an accurate map of the boundary can be created from the information IBEX is able to collect.

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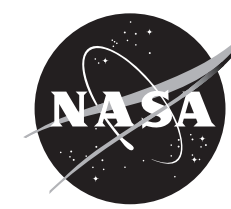
## What is in store for IBEX's future?



Our star, the Sun, as imaged by the SOHO spacecraft. Credit: SOHO (ESA and NASA)

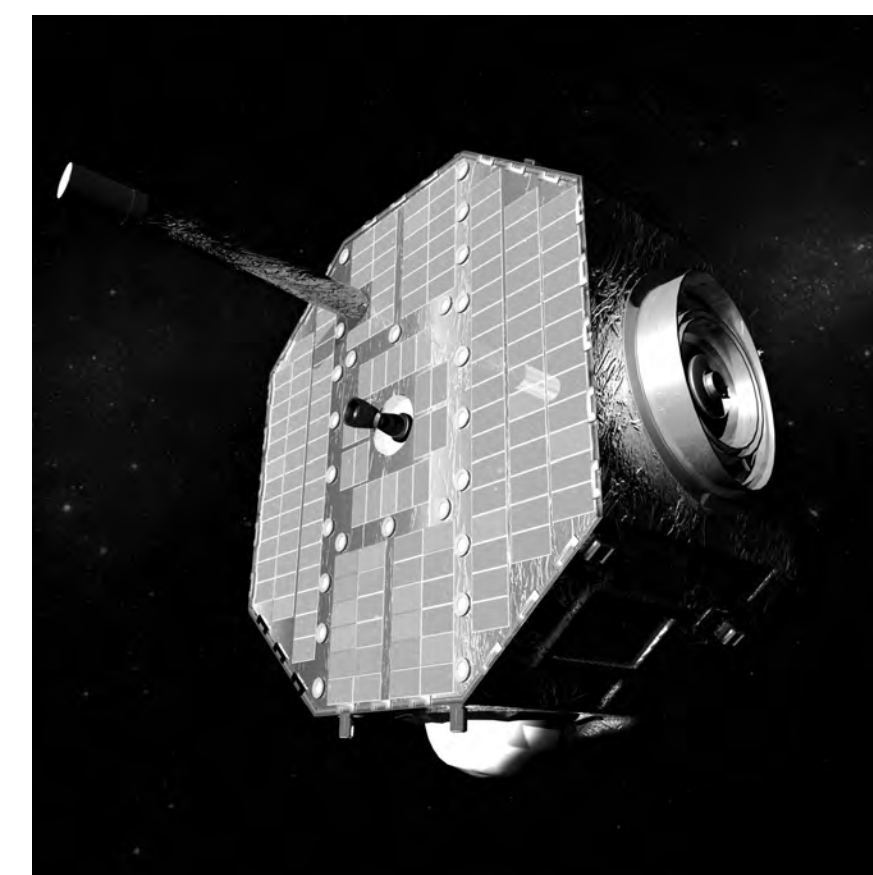
IBEX's primary mission will last for two years. If the spacecraft is healthy in mid-2010, and if NASA's budget permits, then the mission may be extended. From 2008 to 2010, the Sun's activity level will increase, which may push the heliosphere outward and/or change its shape. Because the amount of solar wind particles streaming from the Sun depends, in part, on how active the Sun is, scientists are eager to make several maps of the heliopause, not just one.

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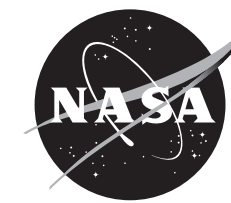
## What will we learn from IBEX?

By analyzing the maps created from IBEX data, scientists can determine what the interaction of the solar wind and the interstellar medium is like in all areas of the heliopause. For example, scientists are trying to find out if there are some areas where the interstellar medium quickly slows the progress of the solar wind or other places where a gradual stop of the solar wind may occur. Also, scientists are trying to determine the overall shape of the bubble.



An artist's rendition of the IBEX spacecraft. Credit: IBEX Team.

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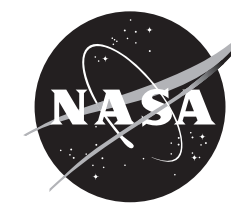


## How does IBEX communicate with Earth?

IBEX completes an orbit every eight days. During each orbit, there is a period of time when the spacecraft is within the Earth's magnetosphere and closer to Earth. At this point, the spacecraft uses antennae that are attached to the outside of the spacecraft to send radio signals to receivers on Earth. Due to the rotation of the Earth each day, the IBEX team needs a global network of receivers so that no matter how the satellite and Earth are lined up, there is a receiver available to accept the signal. IBEX is never far from Earth, so it takes a second or less for signals to travel between IBEX and Earth.

IBEX communications are slow, but they do not need to be on par with DSL connections on Earth. Communication from the satellite to the ground is 320,000 bits of information per second, and from the ground to the satellite is 2,000 bits per second. Compare this to a typical home cable modem connection, where the download speed is often 6 million bits per second, and the upload speed is about 500,000 bits per second! IBEX does not need a high-speed connection, though, since it only has the opportunity to collect up to a few particles per second and does not need to transmit a vast amount of information to Earth. Once on Earth, the signal is carried to the IBEX Mission Control Center in Dulles, Virginia and to the IBEX Science Operations Center in San Antonio, Texas.

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## Activities to do at home:

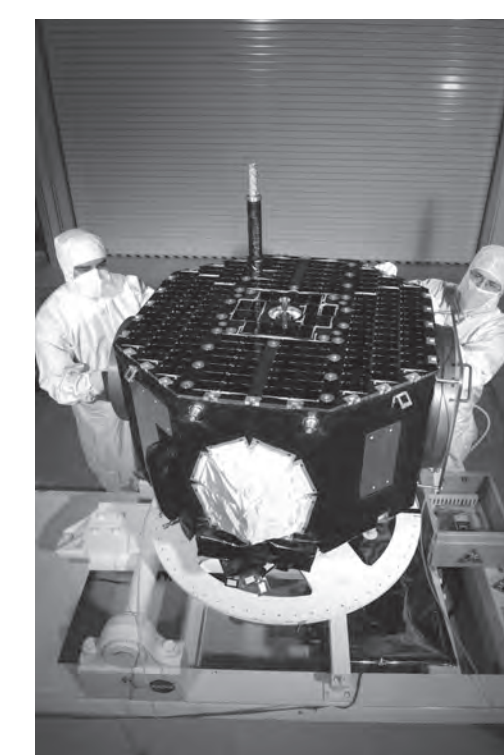
### How big is IBEX?

IBEX is the size of a bus tire or a large semi truck tire. Next time you see one of these tires close up, check it out! As a comparison, the cargo bay of the space shuttle is the size of a bus. IBEX is pretty small, but it can accomplish a lot!

### Sorting Particles

IBEX uses its sensors to sort particles coming from the Solar System's boundary. Try your own sorting activity to see how easy or difficult this might be.

Next time you are walking among a few trees that have lost their leaves, stop and pick up some of the leaves. Sort them by type of leaf if they are from different kinds of trees. Can you tell which trees the leaves came from?



Scientists work on the IBEX spacecraft. Credits: IBEX Team/Orbital Sciences

In the same way you used your hands and eyes as tools to sort leaves, IBEX sorts particles by direction of origin.

### Learn More

For more information, to play games, and sign up for monthly mission updates visit: <http://ibex.swri.edu> Credit: Images available in the public domain through Wikimedia Commons.



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