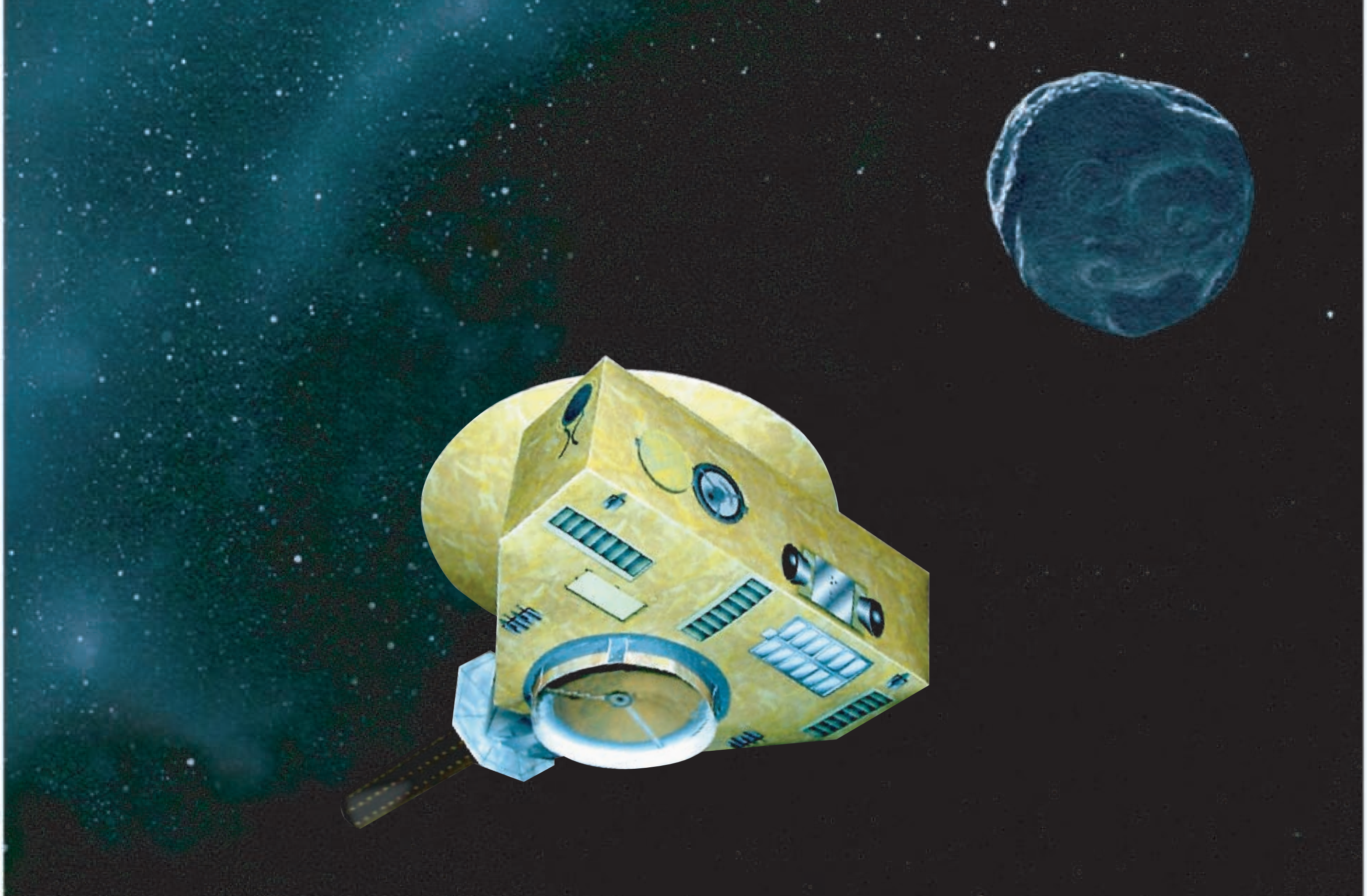
New Horizons

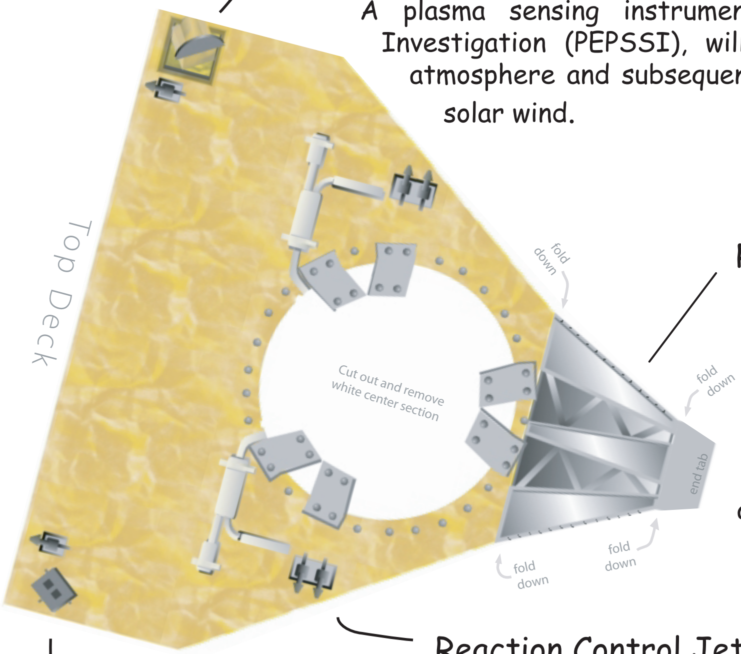
1/25 scale Paper Model

New Horizons is the first mission to the last planet. Build this model of New Horizons and learn about the spacecrafts systems. Then follow the progress of the mission as it swings past Jupiter out to Pluto-Charon and on to the Kuiper Belt.



Parts Set ver 6/26/06

The New Horizons spacecraft is about 6 ft (2 m) on a side and 2 ft (60 cm) tall, about the size and shape of a grand piano. It contains a propulsion system, a thermal control system, redundant computer, navigation and communications sytems, as well as a suite of science instruments, all weighing a mere 1054 lbs (478 kg).



PEPSSI

A plasma sensing instrument, the Pluto Energetic Particle Spectrometer Investigation (PEPSSI), will search for neutral atoms that escape Pluto's atmosphere and subsequently become charged by their interaction with the solar wind.

RTG Mount

This structure, used to mount the RTG power system to the spacecraft, is made out of titanium. The special properties of titanium; high strength per weight and low heat transfer are well suited to supporting the heavy RTG during launch and keeping the very warm RTG from over-heating the spacecraft and instruments

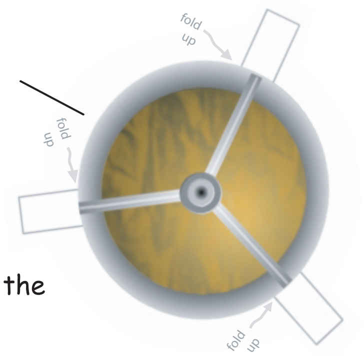
Reaction Control Jets

The New Horizons spacecraft controls its attitude in space through the use of short bursts from these small thrusters arrayed around the vehicle. Each thruster contains a catalytic bed that splits the monopropellant hydrazine into hot component gases which jet out and gently nudge the spacecraft.

Sun Sensor

For maximum data rate the high gain antenna must be kept pointing at Earth. If the spacecraft loses track of its attitude, this Sun Sensor will allow the spacecraft to regain a sun pointing orientation and start an Earth search.

Propellant Tank

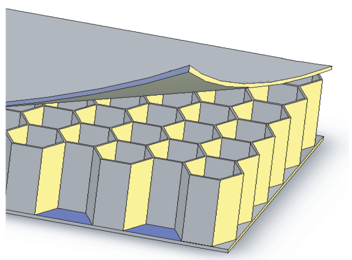


This tank, made of corrosion resistant Titanium and nestled in the center of the spacecraft where it can be kept warm, carries 170 lbs (78 kg) of liquid hydrazine to supply the reaction control jets for the entire 15+ year duration of the New Horizons mission.

Sitting just below the tank is a low gain antenna whichs provides low speed communications with Earth when the spacecrafts high gain antenna is pointing away.

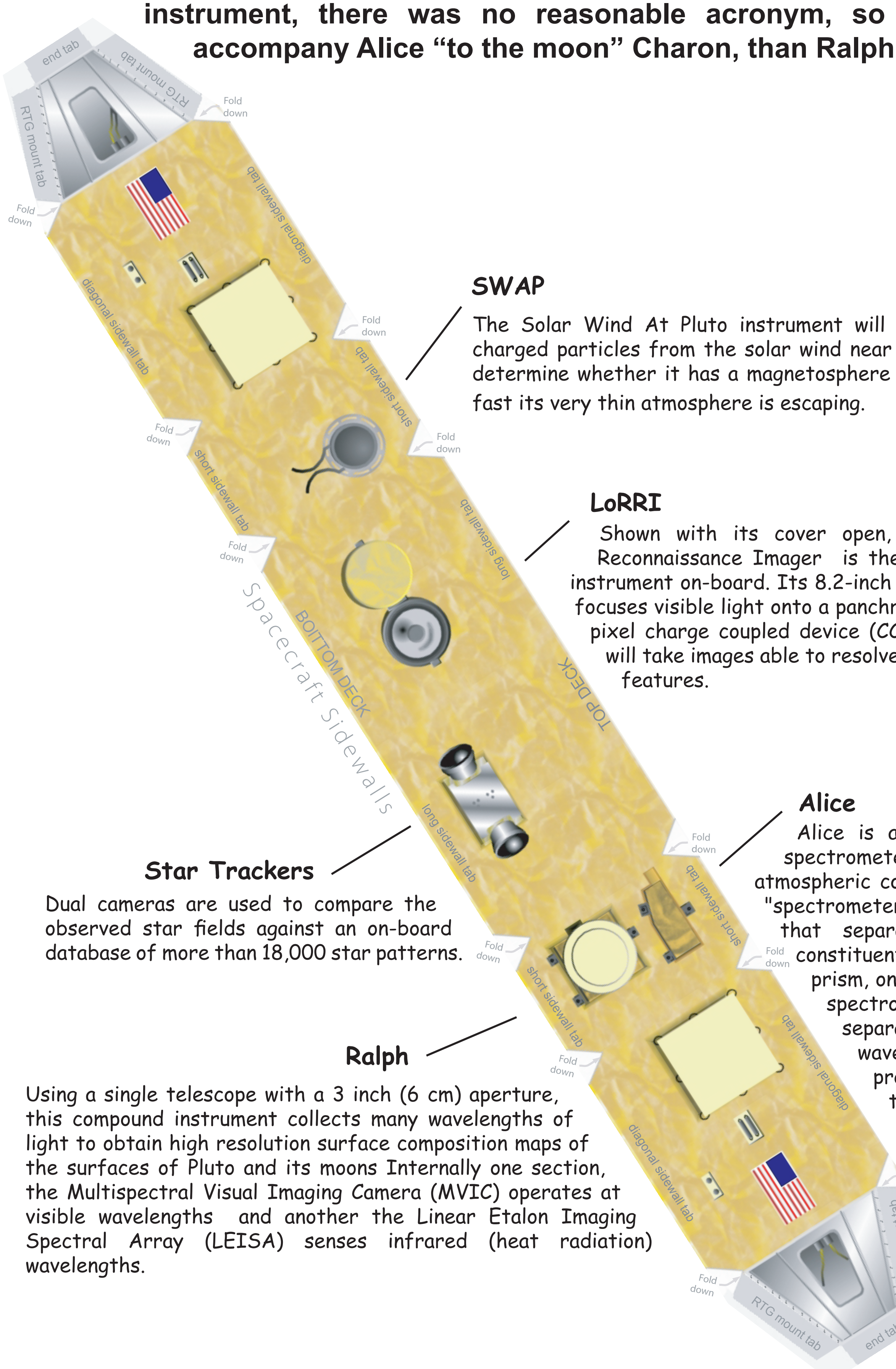
The reaction control system is the sole means the New Horizons spcecraft has to alter its course after it seperates from the launch vehicle 3rd stage. With the ability to change its speed by less than 300 m/s, New Horizons will only be able to alter its course by less than two degrees at Pluto. In-flight manuevers must be carefully budgeted to save propellant for Kuiper Belt Object intercept manuevers.

How to slim-down a spacecraft



The weight of the spacecraft structure is minimized by using honeycomb aluminum panels. The 1” thick panels are made of 1/8“ cell aluminum honeycomb core with 0.005” thick aluminum foil sheets bonded to each face. This design cuts the weight of each panel to 1/9 that of an equally strong solid aluminum panel.

Some of the instrument's names are acronyms made up from longer names, but others are not. In particular the original, longer name of the acronym Alice no longer fits. Likewise when MVIC and LEISA were combined into a new instrument, there was no reasonable acronym, so who better to accompany Alice "to the moon" Charon, than Ralph?



SWAP

The Solar Wind At Pluto instrument will measure charged particles from the solar wind near Pluto to determine whether it has a magnetosphere and how fast its very thin atmosphere is escaping.

LoRRI

Shown with its cover open, the Long Range Reconnaissance Imager is the highest resolution instrument on-board. Its 8.2-inch (20.8 cm) telescope focuses visible light onto a panchromatic 1024 x 1024 pixel charge coupled device (CCD). At Pluto LoRRI will take images able to resolve football-field sized features.

Alice

Alice is an ultraviolet imaging spectrometer that will probe the atmospheric composition of Pluto. A "spectrometer" is an instrument that separates light into its constituent wavelengths, like a prism, only better. An "imaging spectrometer" both separates the different wavelengths of light and produces an image of the target at each wavelength

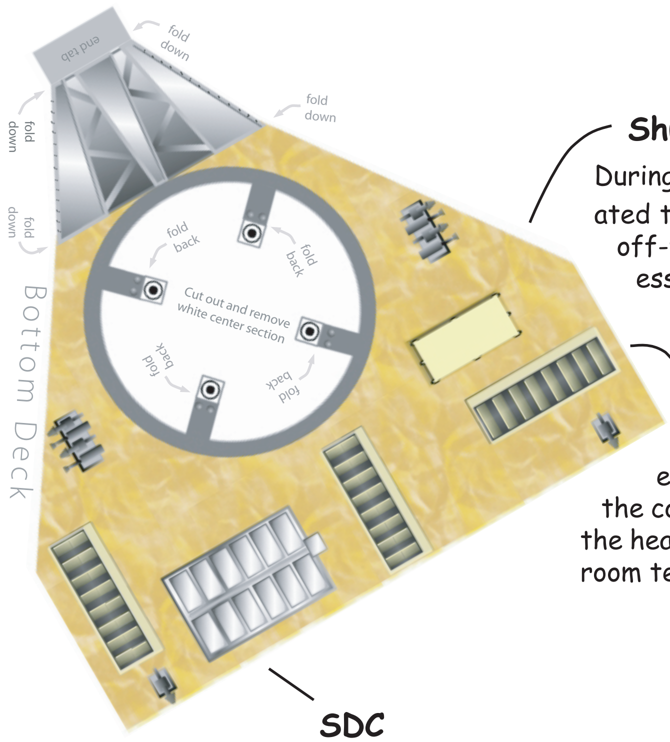
Star Trackers

Dual cameras are used to compare the observed star fields against an on-board database of more than 18,000 star patterns.

Ralph

Using a single telescope with a 3 inch (6 cm) aperture, this compound instrument collects many wavelengths of light to obtain high resolution surface composition maps of the surfaces of Pluto and its moons Internally one section, the Multispectral Visual Imaging Camera (MVIC) operates at visible wavelengths and another the Linear Etalon Imaging Spectral Array (LEISA) senses infrared (heat radiation) wavelengths.

As the New Horizons mission progresses, maintaining the internal temperature is a changing balance between heat production and heat loss. Early in the mission solar heating and excess heat from the RTG power system has to be radiated away. As the spacecraft recedes from the sun and RTG heat production drops, keeping every bit of available heat becomes critical.



Shunt Radiators

During periods of reduced electrical needs excess power is radiated to space as heat. Several of these shunt radiators, painted off-white and located around the outer spacecraft are used to essentially heat deep space.

Louvered Radiators

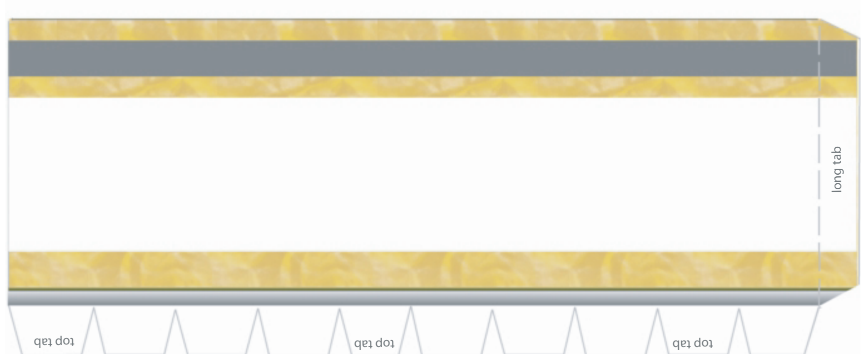
The louvers on these radiators rotate to expose more or less of the underlying surface to the cold of deep space. Using these radiators to control the heat flow the internal temperature is maintained near room temperature.

SDC

The Student Dust Counter, designed, built and operated by students at the University of Colorado, faces in the direction of spacecraft travel so is exposed to dust particle impacts. By studying the distribution of dust left over from the formation of the solar system, we will learn more about the planet formation process.

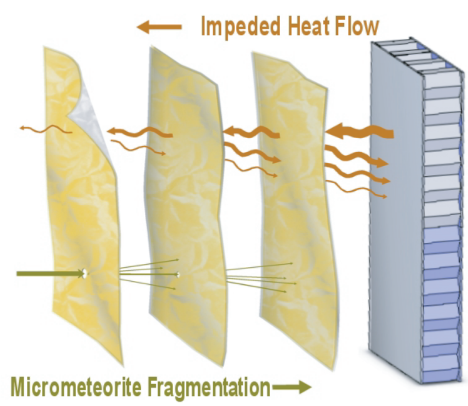
Center Column

The lower edge of the center column mates to the third stage of the New Horizons launch vehicle. It absorbs much of the forces during launch. After third stage burnout, four spring loaded attachment points are released pushing the spacecraft clear of the spent rocket.



Why is it crinkly looking and gold?

To keep heat from escaping to deep space the entire spacecraft is wrapped in Multi-Layer Insulating (MLI) blankets. One side of each mylar layer reflects heat inward and the other resists radiating it outward. The several layers MLI are loosely held ~1.5" (4 cm) apart and off of the spacecraft decks. Once in space the vacuum between the layers prevents heat from conducting between them so the system acts like a thermos bottle inside a thermos bottle.

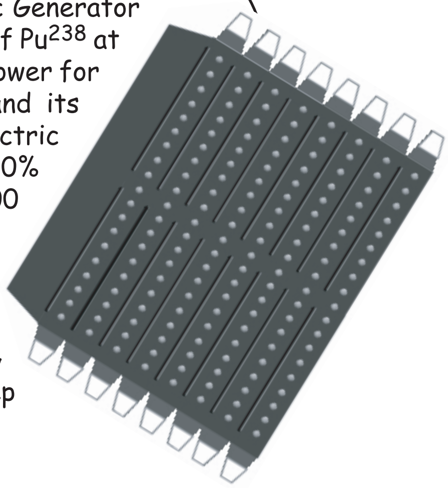


In addition to thermal control the MLI helps protect the spacecraft from micrometeorites. Incoming particles are shattered and lose energy as they penetrate MLI layers. The large spacing between New Horizons MLI layers serves to disperse the shower of penetrating debris over larger areas at the lower MLI layers, spreading out the impact energies.

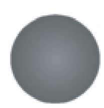
The New Horizons spacecraft and instrument suite were specifically designed to use as little power as possible, even so with everything running they require ~190 watts of electricity. At Pluto the sun is only 1/1000 as bright as it is at Earth making power production with solar cells impractical. Instead New Horizons uses a Radioisotope Thermoelectric Generator (RTG), sometimes called a ‘Space Battery’.

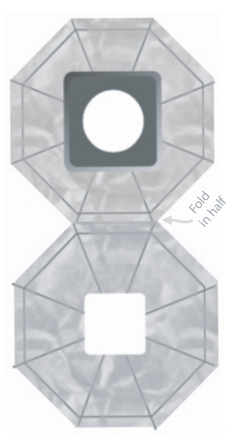
Radioisotope Thermoelectric Generator

The Radioisotope Thermoelectric Generator (RTG) uses heat from the decay of Pu^{238} at its center to produce electrical power for the New Horizons spacecraft and its instrument payload. Thermoelectric junctions are less than 10% efficient, so to produce the 200 watts of electrical power for the spacecraft, the RTG requires more than 2000 watts of thermal energy. Vanes on the exterior surfaces of the RTG dissipate this heat away to deep space.



RTG end cap





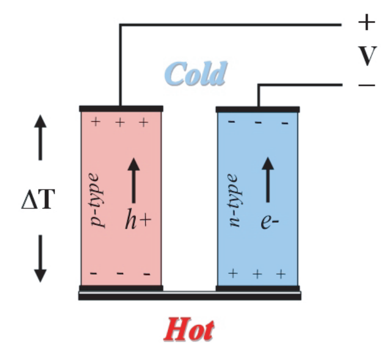
RTG Thermal Shield

This Multi Layer Insulation covered shield prevents the waste heat radiated by the RTG from striking the New Horizons spacecraft. A small amount of heat conducts through the titanium RTG mount into the spacecraft structure and is used to keep the spacecraft electronics from getting too cold.

Electricity from heat?

In thermo-electric junctions, specially formulated materials inhibit atom-to-atom heat transfer relying on mobile electric charge carriers to convey thermal energy.

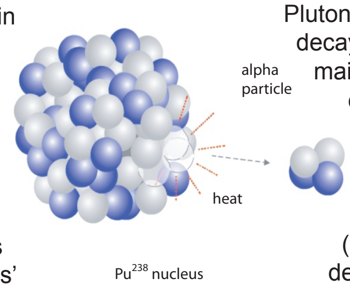
When one end of a junction is warmed and the other cooled, thermally excited electrons from the warm end vibrate about displacing other electrons towards the cooler end. As long as the heat is dissipated away from the cool end, the electrical charge imbalance is maintained and a few volts of electrical potential is produced.



A complementary junction can be made of materials that use positive charge carriers, instead of electrons, to convey heat and charge away from the warm end. Connected beside a junction of the other type a complete circuit can be formed, or multiple pairs can be linked to increase the output voltage.

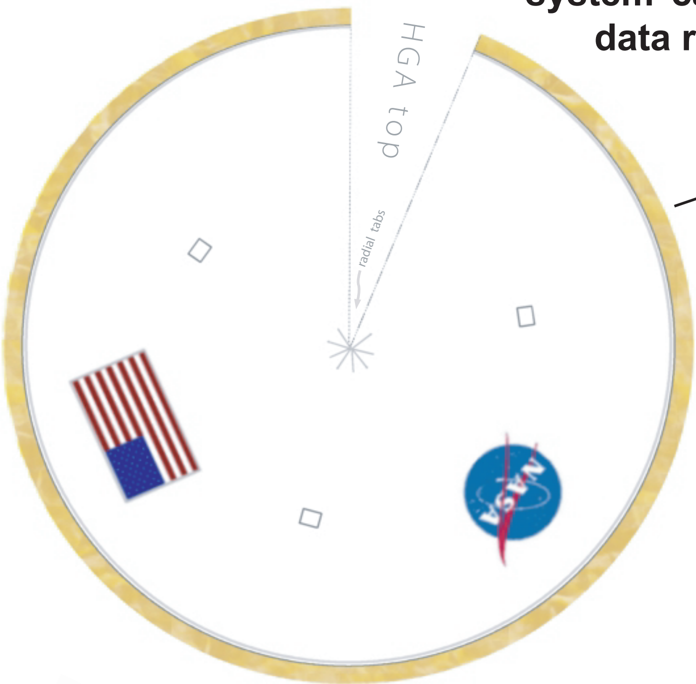
Radioactive Decay

Many elements occur in various different forms, called isotopes, which differ in the number of neutrons in their nuclei. The deficit or surplus of neutrons make the nuclei energetically unstable causing them to, randomly over time, drop or ‘decay’ to more stable states. In decaying to the more stable states the energy difference is released as free particles and heat which ‘radiates’ away.



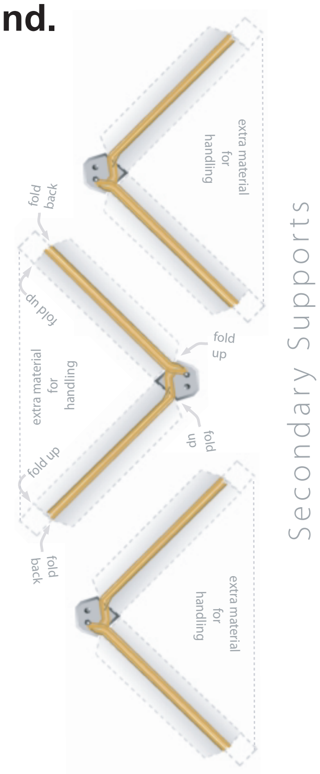
The RTGs on New Horizon use an isotope of Plutonium Pu^{238}, which has 6 too few neutrons. As it decays to a stable state, Pu^{238} emits radiation mainly in the form of alpha particles, which consist of two protons and two neutrons bound together into a particle identical to a helium nucleus. At launch the RTG will produce about 250 watts of electrical power using the heat of Pu^{238} decay. With a Pu^{238} half-life (the time it takes for half of the radioisotope to decay) of 88 years, the RTG power will drop to about 200 watts when New horizons reachs Pluto.

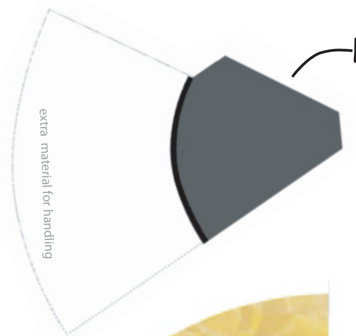
When the New Horizons spacecraft is at Pluto its radio signals will take 4 hours 25 minutes to reach Earth. Along the way the 15 watts from the spacecrafts transmitter will spread out and drop to tens of nano watts collected by the 70m (230 ft) dishes of the Deep Space Network. If there is enough electrical power at Pluto, both halves of the spacecrafts redundant radio system can be used to boost the combined data rate to 1500 bits per second.



High Gain Antenna

The size of the High Gain Antenna (HGA) main dish affects the spacecrafts radio reception and transmission. A larger dish not only collects more incoming signal, it also forms the outgoing signal





HGA Feedhorn

The feedhorn directs the radio signals in and out of the space-craft, between the transmit-ting and receiving electron-ics and the antenna dishes.

HGA Secondary Dish

The secondary dish acts as a reflector between the main dish and the feedhorn. Outbound signals from the feedhorn are turned around at the secondary and spread out to cover the main dish to take advantage of its full size. Incoming signals, reflected and focused by the main dish, are redirected into the feedhorn and the receiving electronics.

REX

The Radio Experiment (REX) sits out in front of the HGA dishes. As the spacecraft passes behind Pluto, with respect to Earth, REX will precisely measure how incoming radio signals are affected by the thin Pluto atmosphere.