**Investigating the Invisible:**

**Radiation Belt Storm Probes**

**Background Information:**

Most of us have seen pictures of other planets and may have even seen beautiful pictures of other galaxies. Pictures give us clues to the mysteries and beauty of our universe.

There are some amazing places in space that don’t have any beautiful pictures taken of them, not because they aren’t just as exciting and mysterious, but because we can’t see them. Believe it or not, a place like this is only several hundred miles\* above our heads, surrounding Earth in two big donut shaped areas! We don’t have any pictures of it but we know it’s there because we can detect it by using tools and observing the effects it has on other things in this region. It’s a mysterious region that changes with the sun’s activity, but we can’t predict what the changes will be. Do you like mysteries? Would you want to go there to find out more?

But, what if you found out that at times this place could become extremely dangerous? That, at times, the mysterious place could suddenly fill with dangerous radiation, (tiny particles with enough energy to knock pieces off of other atoms), that could harm you or destroy your satellite when they hit. Sometimes the size of this area of radiation grows larger, and sometimes shrinks. What would you do? How would you figure out when it was safe, and when you needed to take precautions? Could you do it?

If so, you might like to work on the Radiation Belt Storm Probes team that is doing just that! Surrounding the Earth are two regions called the Van Allen Radiation Belts, named for their discoverer, Dr. James Van Allen. This dynamic and mysterious place was discovered many years ago, but until recently people haven’t had the technology or as much need to investigate it as they do now. Now, with astronauts working in this region and many of our satellites operating there, there is a need to find out more.

But how? What would you do to find out more about this mysterious environment that you can’t detect with just your eyes? Try this activity to see how well you do at being a detective of things you can’t see, then investigate more about the RBSP instruments that are studying the Earth’s radiation belts.

\*Average altitudes above Earth’s surface:

Inner belt: 600-6,000km (373-3730 miles),

Outer belt: 10,000- 65,000km (6,200-40,400 miles)

(See Extension Activity 2 below)

**Teacher Prep 10 minutes:**

1) Collect various familiar objects of differing sizes, shapes, textures, magnetic properties, masses, etc. Items might include, a pencil, a popcorn kernel, a chalkboard eraser, a marble, something made of iron; get creative, but remember to stick with objects your students will be familiar with and that can be tested using various experimental methods (magnetic properties, shaking, finding the mass, microwaving, etc.)

2) Collect the same number of containers. The containers should be big enough to conceal the mystery object but small and light enough for the students to pick up and manipulate. Coffee cans with opaque lids and shoe boxes taped shut work well.

3) Put items in containers so that students can’t use vision to determine what the object is.

4) Mark the containers with special instructions for the particular object inside. For instance, the can might say, “Do NOT microwave” or “shake gently”

\*Remember to consider the properties of both the object and the container when creating your warning labels.

5) Possible Variations/Extensions- Depending upon the level of your students, time constraints, and the objects chosen:

1. Provide a checklist of possible items to make the activity a bit easier.
2. Continue the activity by having students chose the next items to conceal (it’s a good idea to double check any warning labels if the students are selecting the objects).
3. Change or limit the experimental techniques the students are allowed to use. For instance, rather than having open experimentation, perhaps limit the possibilities, for instance in one experiment, the students would only use smell to determine what the object is. (Choose items such as dryer sheets, fresh orange peels, spices.) In another round, students might determine objects only through touch by reaching into the box.

**Activity Time: Variable.** This can be done as a 10 minute introduction or as a full class period with extensions and follow up assignments.

**Activity:**

1) Ask students to think of and record different methods of discovering what the object is before trying their experiment. Emphasize that carefully thinking through and recording their ideas and steps takes patience and may sometimes be more difficult than actually guessing what the object is, however it is an important step in the scientific process that can’t be skipped. Allow students to think of as many experiments on their own as possible, checking with the teacher before doing each one. Students should explain the purpose and thought process behind each test, as well as check for any additional safety precautions.

2) Once students have determined and checked their method of investigation, students should test, and record any observations (clues).

3) At this point they can either guess the object’s identity or design a new test method, record, and experiment again.

4) Students should repeat the process until they have determined what the mystery object is.

5) Give the students time to investigate 1-2 mystery objects (or more depending on available time) then reveal the correct answers, discuss the process and mission connection topics and questions.

**Mission Connection:**

Following the activity, discuss whether some methods were better than others for identifying the mystery objects. Discuss whether it was easy to determine what the object was after just one test, or if it got easier as the clues were pieced together.

*Question: Why would scientists want to have several different types of instruments onboard the RBSP spacecraft?*

Explain the process that the students just did can be compared in some ways to what RBSP scientists and engineers are doing. Even though the Van Allen Radiation Belts are right above our atmosphere, we can’t see them. The RBSP team designed instruments and experiments to discover more about the invisible high-speed protons and electrons, their energies, and the electric and magnetic fields that affect them. We know some things about the radiation belts, but not enough to be able to predict the Van Allen Belts’ behavior. Similar to “Storm Chasers” that investigate extreme weather here on Earth, the RBSP spacecraft will fly into dangerous “space weather” in order to advance our understanding of the processes there. Using information collected by the instruments onboard, the team will piece together the clues and get a greater understanding of this region so close to home and important to our modern way of life.

*Question: If scientists can’t see the radiation belts, how do they know they are there? (Scientists use tools, established methods of measurement, and knowledge built on earlier scientific investigations and discoveries about how the universe works.)*

**Extension Activities:**

1. Have the students choose an RBSP instrument or instrument suite and watch at least 5 questions of their choice from the interviews with the principal investigator. Interviews can be found on the RBSP webpage “Conversation With the Team, Meet the Instrument PI’s” <http://rbsp.jhuapl.edu/mission/conversation/meetPIs/index.php>. Once students learn more about an instrument and the mission, students should share with the class what they discovered.
2. Have students use the sizes of the Van Allen Radiation belts in the Background section above and then find the altitudes or measurements of other familiar places or things to help them understand and better visualize the size and distance of the Van Allen Radiation Belts from the surface of the Earth.

For instance, they may want to find out the measurement from their home to a nearby city. Is it more or less than 366 miles, the average altitude of the inner edge of the radiation belts? What is the diameter of the Earth? Is the Earth bigger or smaller than the highest point of the outer radiation belt? How high is the International Space Station? Does the inner radiation belt ever come closer to the surface of Earth? When it does, do the Astronauts need to take precautions? How far from Earth is the moon, do the radiation belts come close to it?

Communicating Results: After doing research, students should draw or build scale models to portray as accurately as possible what they discover.