Radiation Run: A Matter of Energy

Suggested Grade Level, 5-8th grade, suggested number of players 10-40

Game Overview:

Student learning about the Van Allen radiation belts and the Radiation Belt Storm Probes (RBSP) mission will have key concepts reinforced through this kinesthetic roll play activity that is similar to tag or flag football. Key concepts include; the connection between the Sun's activity and Earth's radiation belts, protecting space based technologies, and the variation in subatomic particle energies within the radiation belts.

This game is designed to be a kinesthetic demonstration of previously learned concepts and represents a simplified version of events within the radiation belts. Background and additional content information, including a classroom power point presentation, resources, and links can be found on the RBSP education website: http://rbsp.jhuapl.edu/education/index.php.

The teacher may decide to discuss the correlation between each part of the demonstration game and the actual science ahead of time, or may decide to ask students to relate the game back to what they previously learned as an assessment. Student Discussion/Assessment questions are included.

Student Objectives:

1. Students will understand that the Sun affects the Earth's radiation belts, and that those effects are not well understood.
2. Students will understand that high energy particle radiation in the radiation belts can be dangerous to space-based technologies.
3. Students will understand that the particles within the radiation belts vary in energy levels and those energy levels can change.

National Science Education Content Standards:

National Research Council, National Science Education Standards, National Academy Press, Washington DC, (1996). National Science Education Standards are available via internet at http://www:nas.edu.

- **Earth and Space Science:** Earth in the Solar System
- **Unifying Concepts and Processes:** Evidence, models, and explanation; Change, constancy, and measurement.
- **Physical Science:** Motions and Forces; Transfer of Energy

Materials:

- Cones or rope to identify boundary of play
- Whistle or other signaling device
- Paper and pen to create the "secret satellite messages"
- Strips of cloth or other "flags"- 2 per satellite, (apx.30 for a class of 30)
- Colored jerseys to identify "high energy particle" players- (apx.15 for class of 30)

Pre-Game Set Up:

- Area of play will simulate one of the Earth's radiation belts. Place cones or rope to create the shape of a giant donut, with an inner and outer circle. The outer boundary should be large enough to incorporate 30 students engaged in a running game similar to tag or capture the flag. The inner circle should be large enough to serve as a small "safe zone" for several students and the game moderator.
- Have students create the secret satellite messages. They should be relatively short and serve as a reinforcement of radiation belt science or RBSP mission concepts. Fun facts from the RBSP website http://rbsp.jhuapl.edu/index.php may be a good resource for secret message ideas.
- Discuss the rules and boundaries of play, and roles of each student. Discuss the ways in which the game is similar and how it is different than actual events in the radiation belts. The teacher may want to copy the description of rules and play, and the related content sections back to back as a one page student reference sheet. They may also want to discuss as a class what the penalty would be if some of the rules are broken, i.e.: becoming a low energy particle, flags removal, etc.
- Divide the class in half.* Half will start as satellites and the other half will start as high energy particles. Explain that some students will become low energy particles as play progresses. The teacher may play the roles of Earth and solar storm unless there are students that would prefer to have a non-running role. *These numbers may be altered to incorporate low energy particles from the start of the game. This is more aligned with actual conditions within the radiation belts. However, pilot tests show that students become quickly bored in the low energy particle role, so the teacher may want to begin having solar storms early in the game so that the same students don't remain in this role for long periods of time.

Description of roles and play:

Satellites: Pass and receive secret messages before having both flags captured by high energy particles. Once receiving a message, report it accurately to Earth. After reporting, return to play and attempt to tell other satellites the message before having both flags captured by. If flags are lost, become a low energy particle.

High Energy Particles: Capture both flags the satellite is carrying before satellites are able to pass the secret message to other satellites and Earth.

Low Energy Particles: Drift, spin, and bounce around the radiation belt until the solar storm gives you the energy to become a high energy particle.

Solar Storm: Blow the whistle periodically to signal all play to pause. Increase or decrease the number of high energy particles by handing out or taking away "energy" t-shirts to students, (or may leave roles as they are). Blow whistle to resume play.

Earth: Stand in center circle and give out and receive messages from satellites. Keep a general count of the number of satellites that have delivered messages and start a new round by giving out a new message when most satellites have reported back.

General Rules:

1. Keep it a non-contact sport, please no tackling or grabbing. We don't want to *really* destroy the satellites. Satellites should keep flags loosely attached and in plain view, particles may only take one flag at a time.
2. All players must stay inside the boundaries at all times or they become low energy particles.
3. Satellites may tell the message to another satellite anywhere within the radiation belt, or they may enter the safety zone of the inner circle for up to 3 seconds to pass messages to Earth or other satellites. If receiving a message, a satellite must leave and complete an orbit around the belt before returning to report the message to Earth.
4. Satellites may enter the inner circle to escape a high energy particle or to rest once per round. Messages cannot be passed in safe mode.
5. High energy particles may not "guard" the inner circle and may not take flags from the satellites as they are entering or exiting the circle.
6. All play stops when the whistle is blown.
7. A round is the time it takes for one message to be passed to all the satellites and to Earth. The next round begins when a new message is given out by Earth.

Related Content

Satellites and Safe Mode:

The Radiation Belt Storm Probes (RBSP) are two spacecraft that will operate within the Van Allen Radiation Belts. They will study and attempt to solve the mysteries happening there. RBSP will be specially made so they can stay there and operate safely even when the radiation gets really intense.

There are many other satellites orbiting the Earth which are involved in other types of data collection and communications. The radiation belts can be very dangerous place to these satellites. Sometimes after a solar storm, particles are accelerated to nearly the speed of light and the number of dangerous particles multiplies too. The radiation belts can swell and sometimes even a new one appears. If a satellite is hit by these particles, it can be damaged or destroyed. If there is enough early warning, satellites can power down into safe mode when a problem is encountered.

High and Low Energy Particles:

Parts of atoms; protons, electrons, and ions exist in the Van Allen Radiation Belts. They move in patterns along Earth's magnetic field lines. Like a bead on a string, they can spin around it and bounce from Earth's north to south poles and back. They can also drift from one magnetic field line to the next, making their way around the globe.

Sometimes some of these particles suddenly speed up and move almost as fast as light. The number of particles can suddenly greatly increase too. We call these super speeders, "particle radiation." They can be really dangerous to anything that gets in the way. Radiation can destroy electronics and cause changes to cells in people. We have clues, but don't understand exactly why the radiation gets so great. RBSP scientists and engineers are trying to solve this and other mysteries about Earth's Radiation Belts.

Solar Storm:

Our Sun is a turbulent stormy place. There are huge explosions called coronal mass ejections (CMEs) that send tons of particles hurling toward us at millions of miles an hour. Luckily, we are in a protected "bubble" inside Earth's magnetic field. We are safe here in the magnetosphere. Some of the particles are able to enter the field through the tail end of the magnetosphere and then they get trapped, in the radiation belts. To find out more go to: http://rbsp.jhuapl.edu/science/overview.php.

We know that solar storms have a big effect on the radiation belts because changes tend to happen after storms. But there is a mystery. Sometimes after a storm, the radiation increases a lot, other times after what seems to be a similar storm, it decreases, and other times it stays the same! Scientists are trying to solve this mystery to the point that we will be able to predict what will happen there after a solar storm.

Earth:

While the Earth itself doesn't give out and receive messages to satellites, satellite operators do. Depending on where the satellite or spacecraft is, it may take a very short time for the message to be relayed, or it may take several hours to go out, and several more for the operator to get data back. Since RBSP is in Earth's back yard, it will only take a short time to relay messages to the tough twin spacecraft.

Student Worksheet

1) How did this game simulate what actually happens inside the radiation belts?

2) Based on what you already knew about the radiation belts, how was this simulation different than reality?

3) What was something new you learned from this activity?

4) If you could, how would you change some part of this game to make it more closely simulate radiation belt phenomena?

5) What is something about this mission or this region of near Earth space that you would like to know more about?

6) Now it's your turn! Design a poster, play, song, game, story, poem, diorama, or activity that accurately reflects the science of the radiation belts. Extra credit will be given if there is evidence of original research. A good place to begin your additional research is the Radiation Belt Storm Probe website: http://rbsp.jhuapl.edu.

TEACHER SUPPLIMENT TO STUDENT WORKSHEET:

The teacher may want to use the student worksheet questions as an individual assessment or as topic questions for a class discussion following the activity.

Student Worksheet Answer Suggestions:

1) Sample answers might include: High energy radiation caused damage to technologies, or there is a connection between solar storms and particle radiation variation.

2) Depending on level of student prior knowledge, sample answers might include answers such as: Actual particles move in certain patterns along magnetic field lines not freely in any direction, or the connection between solar storms and particle acceleration is more complicated than in the game.

3-6) Answers will vary; accept all reasonable answers, with extra credit given for original research.