

COSMIC RAYS AND THE SUN

TEACHER NOTES

DESCRIPTION

From where do cosmic rays come? Can they be from the sun? Or are they from elsewhere but blocked by the sun? Students search for a specific data file in the Cosmic Ray e-Lab and look for evidence of the passage of the sun in the flux measurements derived from this file. Many people new to studying cosmic rays initially *think* that cosmic rays originate in our sun. This activity allows students to investigate this idea and study evidence that can confirm or refute their original understanding. An e-Lab user collected data with the detector in a configuration that allowed the detector's axis to sweep across the sun at local solar noon including data before and after the sun's transit. Data collected at the beginning and end of the sweep provide the "control" or no effect from the sun, while solar noon provides data on effect of the sun.

STANDARDS

Next Generation Science Standards

Science and Engineering Practices

3. Planning and carrying out investigations
4. Analyzing and interpreting data
6. Constructing explanations
7. Engaging in arguments from evidence

Crosscutting Concepts

1. Observed patterns . . . guide organization and prompt questions.
2. Cause and effect . . . investigating and explaining causal relationships

Common Core Literacy Standards

Reading

- 9-12.3 Follow precisely a complex multistep procedure . . .
- 9-12.4 Determine the meaning of . . . domain specific words . . .
- 9-12.7 Translate quantitative or technical information . . .

Common Core Mathematics Standards

- MP2. Reason abstractly and quantitatively.
MP5. Use appropriate tools strategically.
MP6. Attend to precision.

ENDURING UNDERSTANDING

When addressing initial thinking, we use comparison data to make a claim about whether or not the idea is correct. Claims are made based on data that comprise the evidence for the claim.

LEARNING OBJECTIVES

Students will know and be able to:

- Determine the cosmic ray flux over a period of time.
- Interpret plots of cosmic ray flux generated in the e-Lab.
- Organize evidence and construct an argument.

PRIOR KNOWLEDGE

How to conduct research including forming a researchable question, to address a problem to solve. Students will be more successful with some background knowledge on cosmic rays.

BACKGROUND MATERIAL

Cosmic rays arrive at Earth's upper atmosphere from many sources. These charged particles collide with atmospheric gas molecules. The collision destroys the original so-called "primary" cosmic ray and creates

a number of short-lived “secondary” cosmic rays. This activity allows students to look for a difference in the arrival rate of the secondaries when the sun is directly overhead the detector. It allows them to see how much the sun can contribute to (or block) the passage of these particles.

IMPLEMENTATION

Where do cosmic rays come from? Introduce the activity by noting that many people think cosmic rays come from the sun. Is the sun a major contributor to muons detected by our classroom detectors? How would we test that idea? Have students get in groups, find out what they think, and ask them to develop a hypothesis about their ideas. Review how to get the data from the e-Lab and provide the information below about the data they will need. They will gain experience using the e-Lab—searching for data and performing a flux study—to see if the passage of the sun through the detector makes any difference in the arrival rate of the muons.

The students who collected the data set up their detector so that it pointed to the spot on the sky that the sun would pass through at local noon. This arrangement allowed the detector to sample the sky before, during and after the sun passed through the “beam.” Students can study the flux plots to see if there is a difference around the time of local solar noon.

Here are some important details about the data collection protocol:

Location of detector:	Cowley College, Arkansas City, Kansas
DAQ ID:	6202
Longitude of detector:	97:02.5347 W
Latitude of detector:	37:03.6826 N
Dates:	April 24-29, 2014
Local solar noon:	~17.30 UTC for the dates in question

You can provide the time of local noon to the students or ask them to determine it. Here is a useful tool: http://aa.usno.navy.mil/data/docs/RS_OneDay.php

The arrangement of the detector in this study allowed it to “see” about 5° of the sky. The angular diameter of Sun from Earth is about 0.5° . You might ask the students to calculate how long it takes for the sun to move through the viewing area. There are three counters at WC 00 2F, and the first and last counters are separated at 3 m. They could look for any effect in the flux that has a similar duration. You might also recall that Sun is 8 light-minutes from Earth, and these particles are traveling slightly less than the speed of light. The students should discuss whether that has any effect on what they expect to see.

CLAIMS, EVIDENCE & REASONING

Students can easily test their answer to the question about passage of the sun and its effect on the arrival rate of muons. There are three possible answers to the question. They look something like this:

1. Passage of the sun increases the muon flux in the detector.
2. Passage of the sun has no measurable effect on the muon flux in the detector.
3. Passage of the sun decreases the muon flux in the detector.

One of these statements—or their equivalents—is the student *claim*.

Plots of the flux around solar noon are *evidence* for their claim. Students present their evidence by stating what the plot shows. It is NOT sufficient to refer to the plot with no explanation. Interpreting those plots provides the *reasoning* that supports their claim.

ASSESSMENT

In order to test the extent to which the students have either confirmed or refuted their claim, they should answer the question: “Does the passage of the sun through the detector make any difference in the arrival rate of the muons?” What would you tell people who think that cosmic rays originate from our sun? What evidence and reasoning would you provide to support your claim?

This activity is suitable for assessment via a formal or informal lab report in which students state their claim and present and interpret their plots. They could also comment on what they learned about the importance of using data to support or refute initial ideas.

Suggested report template:

1. The question is [teacher-provided or discussion consensus among students].
2. How did you set up your investigation?
3. Your data
4. Your claim (evidence based on the data) and your reasoning (an explanation of how your evidence refutes or supports your claim, alternative explanations, not enough data to make a claim, or why there is not sufficient data)
5. Conclusion (related to the big idea, i.e., idea that cosmic rays come from the sun)

If the students are new to e-Labs and/or writing up reports in this way, they may need a template (see 1-5). The teacher and students will need definitions.