- Cosmic rays -

What can we learn from them?

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Background information for teachers

Overview of this lesson pack:

Name of the lesson pack	**Cosmic rays - What can we learn from them?** Hunting & Monitoring cosmic rays to forecast space weather **Activity 1:** The Icecube Experiment "How can we find evidence of neutrinos?" **Activity 2:** Smartphone cosmic rays detector "And if we could turn our smartphone into a cosmic ray-detector?" **Activity 3:** Space weather forecast with cosmic rays data "How can cosmic rays help us space forecasting to predict Geomagnetic storms and solar particle event that may disrupt planets entire communication and electrical grids?"
Topics introduced	**Activity 1:** Matter and antimatter, neutrinos, speed of light, conservation of energy **Activity 2:** Cosmic rays, neutrinos, muons, speed of light, conservation of energy **Activity 3:** Cosmic rays, neutrinos, muons, geomagnetic storms, space weather, aurora borealis

Overview of this lesson pack:

Curriculum Connection (Activity 1) **The Icecube Experiment** *"How can we find evidence of neutrinos?"*	**Learning outcome**: To build 21st century STEM skills **Data Literacy**: Collect the data and what parameters must be taken into account while working with the particular data and how to conclude their inferences. **Digital Literacy**: Learn to handle different tools to collect data. **Collaborative skills:** Collaborate with each other. **Learning goal:** Realise that the fact that we exist is because matter is more than antimatter and one way to study this is by studying neutrinos and antineutrinos. **PORTUGAL**: 7th grade Physics and Chemistry (Space - Big Bang, Solar System (Sun); 7th and 10th (Energy - sources and processes) and 8th grade (Chemical Reactions (atoms, ions) and Light); 9th grade - Geography (Environment and Society - Weather (atmosphere) and 9th/ 10th grade Physics and Chemistry (Atom structure); 12th grade Physics (Modern Physics - quantum physics and radioactivity). **GREECE**: 3rd, 5th grade high school - Physics (negative/positive charge -> matter/antimatter -> neutrino/antineutrino), 1st grade high school - Geology (layers of atmosphere: ionosphere->ions and electrons->neutrinos), 2nd grade high school - Physics (energy conservation: basic principle on the high energy physics experiments) **PAKISTAN**: high school, 12 to 15 years old - Physics (Atomic physics (Introductory level), Radioactivity) **ROMANIA**: 6th grade- Physics (Atom structure), 8th grade- Physics (Energy and Life), 12th grade-Physics (Atomic Physics, Nuclear Physics) **BRAZIL**: High school, 12-15 yrs (Energy conservation, structure of matter, photons , eletromagnetic spectrum, radioactivity; ionization-).

Overview of this lesson pack:

Curriculum Connection (Activity 2) **Smartphone cosmic rays detector** *"And if we could turn our smartphone into a cosmic ray-detector?"*	**Learning outcome**: To build 21st century STEM skills. **Data Literacy:** Collect the data and what parameters must be taken into account while working with the particular data and how to conclude their inferences. **Digital Literacy**: Learn to handle different tools to collect data. **Collaborative skills:** Learn how to contribute to Citizen Science Project which helps them to better understand the significance of collaboration in promoting science. **Learning goal:** Understand the different particles that surround us and their sources. **PORTUGAL**: 7th grade Physics and Chemistry (Space - Big Bang, Solar System (Sun)); 7th and 10th (Energy - sources and processes); 8th grade (Chemical Reactions (atoms, ions) and Light); 9th grade - Geography (Environment and Society - Weather (atmosphere) and 9th and 10th Physics and Chemistry (Atom structure); 12th grade Physics (Modern Physics - quantum physics and radioactivity). **GREECE**: 5th grade high school - Physics (light, UV/IR -> cosmic rays) 1st grade high school - Geology (layers of atmosphere: ionosphere->ions and electrons-> cosmic rays). **PAKISTAN**: high school students, 15-18 yrs - Physics (Radioactivity -Natural and Background radiations, Geiger Muller Counter, Atomic Physics, Modern Physics (Introductory level)). **ROMANIA**: 8th grade- ICT (integrated in the general competency 3 as interdisciplinary project), 6th grade - Physics (Electric and Magnetic Phenomena, Measurement and Errors), 12th grade - Physics (Atomic Physics, Nuclear Physics) **BRAZIL**: High school, 15-18 yrs (Introduction to Modern Physics, Quantum Mechanics, Nuclear Force, Radioactive decay, Elementary Particles, Eletromagnetism-Magnetic Field).

Overview of this lesson pack:

Curriculum Connection (Activity 3) **Space weather forecast with cosmic rays data** *“How can cosmic rays help us space forecasting to predict Geomagnetic storms and solar particle event that may disrupt planets entire communication and electrical grids?”*	**Learning outcome**:To build 21st century STEM skills. **Data Literacy**: Collect the data and what parameters must be taken into account while working with the particular data and how to conclude their inferences. **Digital Literacy**: Learn to handle different tools to collect data. **Collaborative skills:** Collaborate with each other. **Learning goal:** use cosmic rays data to space forecast and predict geomagnetic storms and solar particle events. **PORTUGAL**: 7th grade Physics and Chemistry (Space - Big Bang, Solar System (Sun); 7th and 10th (Energy - sources and processes) and 8th grade (Chemical Reactions (atoms, ions) and Light); 9th grade - Geography (Environment and Society - Weather (atmosphere and space weather), Risks and Natural Disasters (solar storms)) and 9th and 10th Physics and Chemistry (Atom structure); 12th grade Physics (Modern Physics - quantum physics and radioactivity). **GREECE**: 1st, 2nd grade high school- Geography/Geology (different climates, weather -> space weather). **PAKISTAN**: high school students aged 16-18 yrs. Measurement and Errors, Radioactivity -Natural and Background radiations, Geiger Muller Counter,Magnetic field and field lines,Atomic Physics,Modern Physics (Introduced at very basic level). Geography- Aurora Borealis,Weathers **ROMANIA**: 5th grade-Geography (Weather and climate), 8th grade-Chemistry (Chemical Reactions), 6th grade-Physics (Electric and Magnetic Phenomena, Measurement and Errors), 12 grade-Physics (Atomic Physics, Nuclear Physics) **BRAZIL**: high school (Introduction to modern physics, quantum mechanics, nuclear force, radioactive decay, elementary particles)

Overview of this lesson pack:

Reference Demonstrator	Cloud chamber: http://www.frontiers-project.eu/demonstrators/cloud-chamber/
Age of students	13 to 18 yr
Duration	2 to 3 hours per activity
Type of activities	Hands-on activities with inquiry-based learning

Overview of this lesson pack:

Description of activity - Teachers	**Activity 1: The Icecube Experiment "How can we find evidence of neutrinos?"** This activity aims to make learning meaningful and students should recognize the importance of science participation and explore information related to the IceCUBE detector. • https://www.nature.com/articles/d41586-020-01022-3 • https://futurism.com/why-do-we-want-to-find-neutrinos • https://home.cern/news/news/experiments/cern-connects-icecube-bring-science-schools • https://icecube.wisc.edu/about/overview • https://icecube.wisc.edu/info/neutrinos • https://www.youtube.com/watch?v=o4S2nkTsHW8 • https://sciencenode.org/feature/Putting%20neutrinos%20on%20ice.php **Activity 2: Smartphone cosmic rays detector "And if we could turn our smartphone into a cosmic ray-detector?"** Introduce the acronym CREDO (Cosmic-Ray Extremely Distributed Observatory) and its purpose: collaboration between enthusiastic scientists and citizen scientists from all around the globe for a hunt of cosmic particles. Its objective is to find cosmic particles and their possible connections to Dark Matter ● https://www.youtube.com/watch?time_continue=26&v=6rHnW--PZQk&feature=emb_logo ● https://credo.science/testnowy/cosmic-ray-extremely-distributed-observatory-credo/ ● **CRL Cosmic Ray Live** ● https://play.google.com/store/apps/details?id=com.DigitalComoedia.CosmicRaysLive&hl=en **Activity 3: Space weather forecast with cosmic rays data "How cosmic rays help us space forecasting to predict geomagnetic storms and solar particle event that may disrupt planets entire communication and electrical grids?"** Introduce students to September 1859 Geomagnetic Storm which help students understand the necessity to monitor cosmic rays. Explain the Cosmic Ray Data Applications to Space Weather Forecasting. ● http://www.sws.bom.gov.au/World_Data_Centre/1/7 ● https://www.sws.bom.gov.au/Geophysical/1/4

Overview of this lesson pack:

Description of activity - Students	**Activity 1: The Icecube Experiment "How can we find evidence of neutrinos?"** The students watch the video will be proposed for introduce the concept of subatomic particles, cosmic rays and their detection through the observatory IceCUBE https://www.youtube.com/watch?v=aMnGWqoDaAA https://www.youtube.com/watch?v=nkydJXigkRE https://www.youtube.com/watch?v=o4S2nkTsHW8 Then take the quiz to learn about elementary particles: https://scoollab.web.cern.ch/sites/scoollab.web.cern.ch/files/ParticleGame/ After some initial reflection, students will work within a group as a team to work on the following hands-on activities: ● Popcorn experiment: https://icecube.wisc.edu/outreach/activity/popcorn_neutrinos ● More Neutrinos activities: https://icecube.wisc.edu/outreach/activities **Activity 2: Smartphone cosmic rays detector "And if we could turn our smartphone into a cosmic ray-detector?"** The students watch the video https://www.youtube.com/watch?v=4riZZANp1X4 to understand what they have to do. Then, students download the CREDO application on their mobile devices; create an account and run the application that can be found at Play Store "Science CREDO Mobile Detector" and explore the app. **Activity 3: Space weather forecast with cosmic rays data "How cosmic rays help us space forecasting to predict geomagnetic storms and solar particle event that may disrupt planets entire communication and electrical grids?"** Students will watch the video https://www.youtube.com/watch?v=oHHSSJDJ4oo to understand space weather, Auroras Borealis, Solar magnetic storms and its effect on Earth. Then students will follow the link to get answers for frequently asked questions and connections to Space weather https://www.nasa.gov/mission_pages/sunearth/spaceweather/index.html

Overview of this lesson pack:

Equipment requirements	**Activity 1**: 2 kinds of popcorn, popcorn popper, balance Worksheet for each group/student (Popcorn neutrinos) **Activity 2**: Mobile devices with internet connection **Activity 3**: PC with internet connection. Graph paper to plot the data
Prior knowledge for students	**Activity 1:** Atomic structure (protons, neutrons, electrons), energy balance, average value **Activities 2 and 3**: Cosmic rays, photons, plasma,magnetic field and field lines

Presentation for students

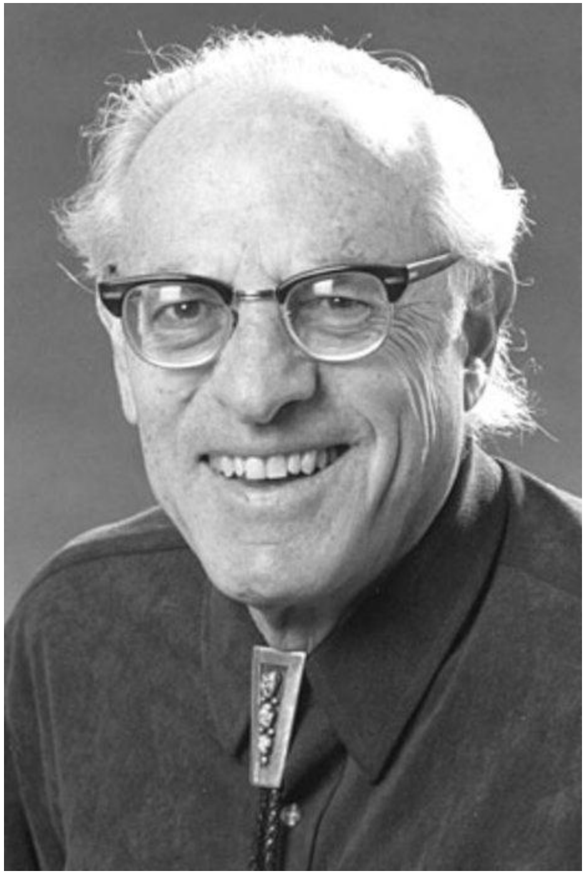
Teacher guidelines can be found in the notes attached to each slide

"Lights" from our past...

FRONTIERS

When radiation and atoms interact, charged atoms, ions, are often produced. In 1912 **Victor Hess** measured atmospheric ionization as function of altitude using balloons. Surprisingly, he found that ionization first decreased, but then increased again at higher altitudes. He concluded that the upper atmosphere is ionized by radiation from space. He proved that this radiation is not solar through experiments performed at night and during eclipses: cosmic rays had been discovered. **The Nobel Prize in Physics 1936**

The **Nobel Prize in Physics 1945** was awarded to **Wolfgang Pauli** "for the discovery of the Exclusion Principle, also called the Pauli Principle."



The **Nobel Prize in Physics 1995** was awarded "for pioneering experimental contributions to lepton physics" jointly with one half to Martin L. Perl "for the discovery of the tau lepton" and with one half to **Frederick Reines** "for the detection of the neutrino."

Activity 1

The Icecube Experiment

"How can we find evidence of neutrinos?"

By the end of this activity...

Students should be able to:

- realize that everything around us is made of matter.
- understand the concept of antimatter (similar properties with matter, but opposite charge) and that if there were equal amounts of matter and antimatter then there would only by light.
- understand that one way to study differences between matter and antimatter is to study neutrons and antineutrons.
- investigate the concepts behind beta decay, neutrinos and the South Pole IceCube Project that is searching for neutrino sources in the universe.

Background

- The first law of thermodynamics, also known as the law of conservation of energy, states that energy can neither be created nor destroyed. This lab models a reaction in which there was an apparent loss of energy, which led to the discovery of a particle called a neutrino.

- In 1931, study of nuclear reactions showed that when a neutron changed into a proton in a process called ‘beta decay’, it released an electron which called a beta particle. However, careful measurements showed that the proton and the beta particle together had slightly less energy than the original neutron.

- This led Wolfgang Pauli, an Austrian theoretical physicist, to propose that another particle was released during beta decay, which carried the missing energy. Since the particle would have to have a neutral charge and small mass, it was called a neutrino (which means ‘little neutral one’). It wasn’t until 1956 that scientists first experimentally detected a particle fitting these characteristics.

Worksheet

FRONTIERS

IceCube

Popcorn Neutrinos

At a glance

By measuring popcorn before and after popping, students will investigate the concepts behind beta decay, neutrinos and the South Pole IceCube Project which is searching for neutrino sources in the universe.

Background

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In 1931, study of nuclear reactions showed that when a neutron changed into a proton in a process called 'beta decay', it released an electron which is called a beta particle. However, careful measurements showed that the proton and the beta particle together had slightly less energy than the original neutron.

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Time

Preparation: ~1 hour

Class time: Two 50 minute class periods

Materials

Per class

- 2 types of popcorn (such as two different brands or varieties white, yellow, black)

Per group of students

- Popcorn popper (Air poppers are easiest to use because they do not need oil)
- Popcorn (~40-100 grams per team, depending upon the popcorn popper)
- Container for kernels and container for popped corn
- Data recording sheet, student notebook, or computers with spreadsheet software
- Balance (sensitive enough to measure to at least 0.1 g, and preferably to 0.01 g)

Advanced Preparation

Before the lab:

1. Get the popcorn, the popcorn poppers (poppers may be either purchased – e.g., at thrift stores, or brought in by the students), and the balances.
2. Try the experiment in advance to become familiar with it.
3. Test the circuits to make sure there is enough wattage for all popcorn poppers simultaneously.

Directions

1. Ask the students if they think popcorn weighs the same, more, or less after it is popped. Have them make a prediction and explain their reasoning.
2. Ask them how they could test their predictions. What equipment will they need? How will they control the variables?
3. Remind them of the safety precautions and discuss the importance of accurate data collection and recording. (Don't eat the popcorn before measurements are complete!)
4. Review the proper use of the balances and the popcorn poppers, then divide the students into teams and give each team 40-100 grams of popcorn (depending on the type of popper being used), and a balance. Give half of the teams one kind of popcorn, and half the other kind.

IceCube

5. Have the students count out and weigh 100 kernels.
6. Each group should pop all their corn and weigh 100 pieces of popped popcorn.
7. While the students are doing the experiment, circulate among the teams and ask them guiding questions such as:
   - Why not pop just one kernel?
   - According to the data, is your hypothesis correct? Did the mass of the kernels increase, decrease, or stay the same?
   - What are the variables in this experiment?
   - What difficulties did you encounter? How were you able to overcome them?
8. After all the groups are done with the experiment, bring the whole class together to discuss the results. Have them calculate the average mass of one kernel before and after popping, and the average mass change.
9. Tell the students about the discovery of neutrinos and ask them how the experiment they just conducted relates to this discovery.
10. Discuss how neutrinos are being used to 'map' part of the universe and why Antarctic is the ideal place for this kind of study.

Caution

If you are going to allow the students to eat the popcorn, take special precautions to wash lab tables, have clean containers, wash hands, and stress that students not eat the popcorn until after all the measurements are taken.

Discussion

1. How many teams found a gain in mass? A loss? The same mass? Why might teams get different results? (Get beyond 'bad measurements' – some possibilities are: Variations in popcorn, popcorn popper temperature, or speed of popping, and what the group decided to count, e.g. what to do in terms of data and calculations with unpopped or partially popped corn.)
2. What variables affected the results of this experiment? Would it matter if new or old corn was used? Why?
3. According to the Law of Conservation of Mass, can mass be lost? If mass was lost, where did it go? (The students should figure out that the 'lost' mass is due to the water contained in the kernel escaping as steam.)
4. How is this experiment an analogy for the beta decay process?
5. It took scientists a long time between proposing the neutrino as a hypothetical particle and collecting evidence which proved its existence. Are there other outstanding open questions in physics or science, where a theoretical answer is in place, but the evidence needed to prove the theory is lacking?

Extensions

- Use a video camera to record individual corns popping (probably from a flat pan, beware of spattering oil. Use a motion analysis software (LoggerPro by Vernier Software) to make quantitative measurements of energy. Many individual energy estimates can be combined to produce an energy spectrum for the popped corn. This work should produce a data set suitable for statistical analysis.
- Calculate the initial pressure inside the kernel, based on available quantitative measurements and reasonable quantitative assumptions.
- Develop a method to collect, condense, and weigh the water vapor released by the popping corn. Re-examine the earlier conclusions about conservation of mass vs. mass loss with this new information.
- Prepare popcorn kernels with different moisture levels (using different times in a drying chamber or low temperature oven) and compare mass loss and/or popping energy spectra.
- Invent a way to damage the seed coats of the popcorn, and examine the effect of this damage on popping. Challenges include being able to quantify both the extent of the damage, and the effect on popping.
- Use an infrared camera to collect pictures of the popped kernels. What new kinds of analysis are possible with this new way to look at this phenomenon?

Links

IceCube Neutrino detector website: www.icecube.wisc.edu
IceCube Education & Outreach site: www.icecube.wisc.edu/outreach/
YouTube Movie about the detector: www.youtube.com/watch?v=nx5wphtHBZQ
Popcorn popping in super-slow motion: www.youtube.com/watch?v=CXDstfD9eJ0

FRONTIERS

Activity 2

Smartphone cosmic rays detector

“And if we could turn our smartphone into a cosmic ray-detector?”

By the end of this activity...

Students should be able to:

- Understand what is CREDO and what its purpose.
- Describe cosmic particles and their detection as well as their possible connections to Dark Matter.
- Participate actively in citizen science projects.

Background

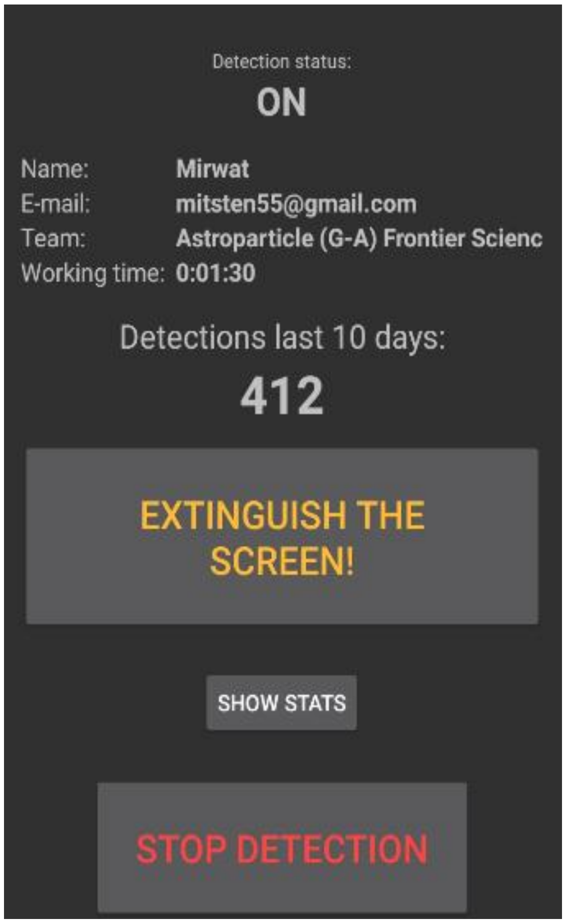
- Although the cosmic rays were discovered at the beginning of the 1900, they remained a mystery for almost a century.
- Cosmic rays are atom fragments that rain down on Earth from outside our Solar System.
- In 2017 scientists from Pierre Auger Observatory (Argentina) concluded that there is a difference in how frequently these cosmic rays arrive: it depends on where you look, and this might be the key to find out from where they come from.
- This knowledge is important not only to astronomy: in November 2017, an international team reported in the Nature journal that by tracking the movement of muons they have found an empty space inside the Great Pyramid of Giza, this might lead us to the idea that muons can reveal the density of an object.

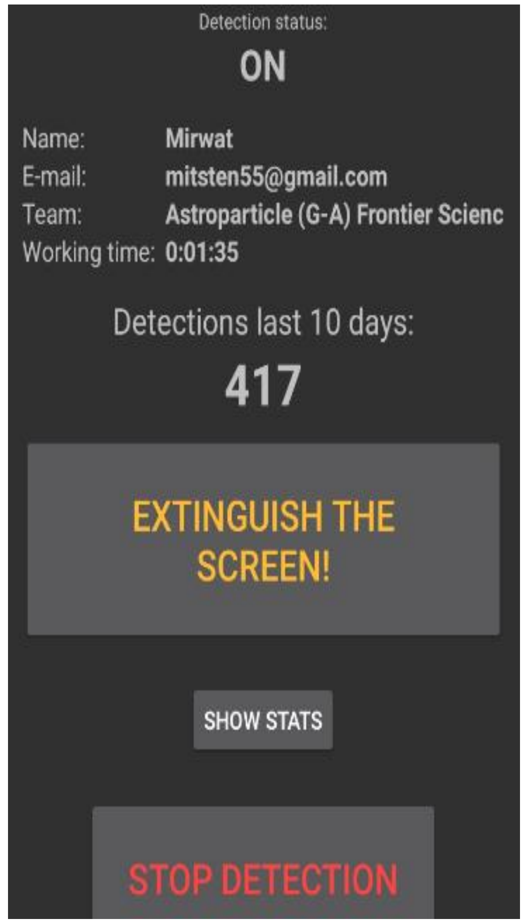
Working Methodology

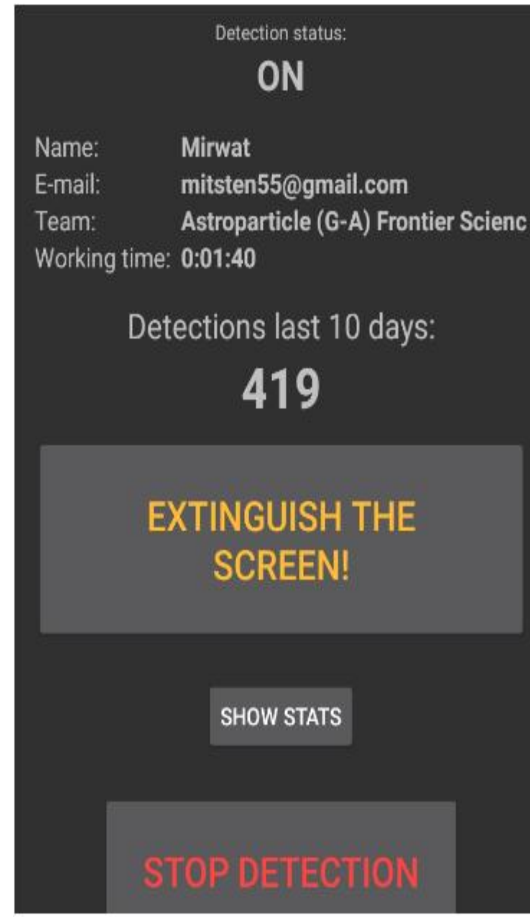
Steps to make:

1. Take your best friend(s) and form a team!
2. Visit the website https://credo.science/credo-detector-mobile-app/
3. Download on your Android device the CREDO app https://play.google.com/store/apps/details?id=science.credo.mobiledetector and register your team.
4. Visit https://api.credo.science/web/ to see your rank on helping Citizen Science and watch it develops.
5. Spread the word and let the war of Cosmic Rays begin!

Cosmic count registered for every 5 second interval







Activity 3

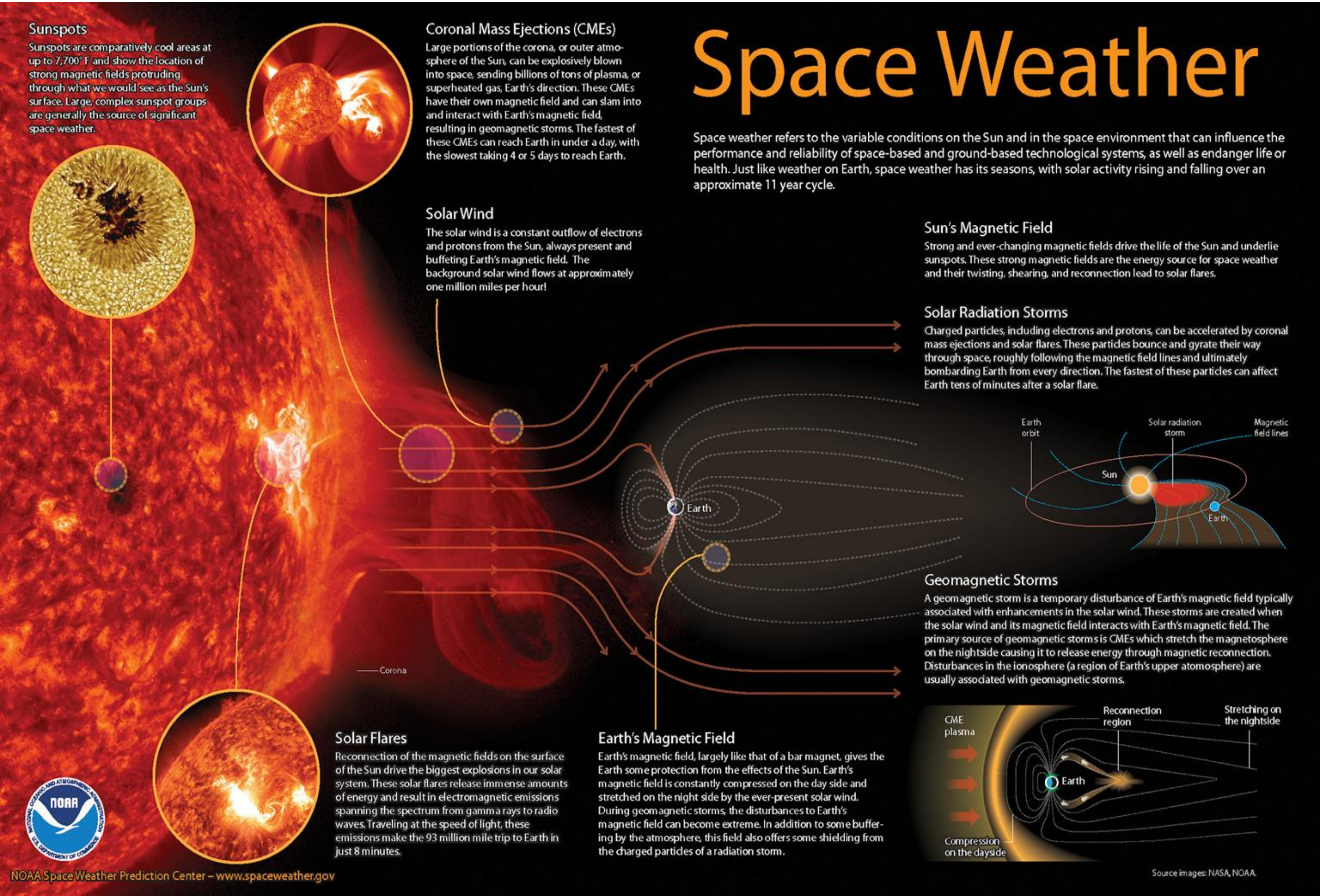
Space weather forecast with cosmic rays data

"How can cosmic rays help us space forecasting to predict Geomagnetic storms and solar particle event that may disrupt planets entire communication and electrical grids?"

By the end of this activity...

Students should be able to:

- Understand what are Geomagnetic Storms and their risks in light of September 1859 event.
- How violent could Solar storms be?To what extent could these disrupt life on earth.
- Explain how Aurora Borealis (Northern lights) are formed and how one would predict them.
- Explore Cosmic Ray Data Applications to Space Weather Forecasting.


Space Weather
Space weather refers to the variable conditions on the Sun and in the space environment that can influence the performance and reliability of space-based and ground-based technological systems, as well as endanger life or health. Just like weather on Earth, space weather has its seasons, with solar activity rising and falling over an approximate 11 year cycle.
Sunspots
Sunspots are comparatively cool areas at up to 7,700° F and show the location of strong magnetic fields protruding through what we would see as the Sun's surface. Large, complex sunspot groups are generally the source of significant space weather.
Coronal Mass Ejections (CMEs)
Large portions of the corona, or outer atmosphere of the Sun, can be explosively blown into space, sending billions of tons of plasma, or superheated gas, Earth's direction. These CMEs have their own magnetic field and can slam into and interact with Earth's magnetic field, resulting in geomagnetic storms. The fastest of these CMEs can reach Earth in under a day, with the slowest taking 4 or 5 days to reach Earth.
Solar Wind
The solar wind is a constant outflow of electrons and protons from the Sun, always present and buffeting Earth's magnetic field. The background solar wind flows at approximately one million miles per hour!
Sun's Magnetic Field
Strong and ever-changing magnetic fields drive the life of the Sun and underlie sunspots. These strong magnetic fields are the energy source for space weather and their twisting, shearing, and reconnection lead to solar flares.
Solar Radiation Storms
Charged particles, including electrons and protons, can be accelerated by coronal mass ejections and solar flares. These particles bounce and gyrate their way through space, roughly following the magnetic field lines and ultimately bombarding Earth from every direction. The fastest of these particles can affect Earth tens of minutes after a solar flare.
Earth orbit
Solar radiation storm
Magnetic field lines
Sun
Earth
Earth
Corona
Geomagnetic Storms
A geomagnetic storm is a temporary disturbance of Earth's magnetic field typically associated with enhancements in the solar wind. These storms are created when the solar wind and its magnetic field interacts with Earth's magnetic field. The primary source of geomagnetic storms is CMEs which stretch the magnetosphere on the nightside causing it to release energy through magnetic reconnection. Disturbances in the ionosphere (a region of Earth's upper atomosphere) are usually associated with geomagnetic storms.
CME plasma
Reconnection region
Stretching on the nightside
Earth
Compression on the dayside
Solar Flares
Reconnection of the magnetic fields on the surface of the Sun drive the biggest explosions in our solar system. These solar flares release immense amounts of energy and result in electromagnetic emissions spanning the spectrum from gamma rays to radio waves. Traveling at the speed of light, these emissions make the 93 million mile trip to Earth in just 8 minutes.
Earth's Magnetic Field
Earth's magnetic field, largely like that of a bar magnet, gives the Earth some protection from the effects of the Sun. Earth's magnetic field is constantly compressed on the day side and stretched on the night side by the ever-present solar wind. During geomagnetic storms, the disturbances to Earth's magnetic field can become extreme. In addition to some buffering by the atmosphere, this field also offers some shielding from the charged particles of a radiation storm.
NOAA Space Weather Prediction Center – www.spaceweather.gov
Source images: NASA, NOAA

Background

- Cosmic rays consist mainly of protons
- They originate from galactic cosmic radiation or from the Sun
- Cosmic rays are observed indirectly by a device known as a neutron monitor
- When cosmic ray particles enter the Earth's atmosphere they interact with the nuclei of the air molecules to produce secondary radiation.
- The neutrons predominate in this secondary radiation.
- The cosmic ray detector actual detects these secondary neutrons and as a consequence is referred to as a neutron monitor.

Forbush Decrease Event

The magnetic fields entrapped in and around coronal mass ejections exert a shielding effect on the galactic cosmic radiation (GCR) which is detected by the neutron monitors. This causes a reduction in the count rate from the monitor. The reduction is typically from about 3 to 20%. It must be at least 3% for a Forbush decrease alert to be issued.

Detection of a Forbush Decrease is in use at the SWS ASFC for assistance in prediction of geomagnetic storms.

Ground Level Event

In this case, an increase in detector count rate is not due to galactic cosmic radiation, but to the addition of solar cosmic (high energy) radiation (solar cosmic rays) from an previous solar particle event (SPE). The increase in the count rate may be from about 3 to 10,000%.

Working Methodology

Steps to be taken:

1-Students would select one of the two given stations i-e Mawson or Kingston from *WORLD DATA CENTRE* http://www.sws.bom.gov.au/World_Data_Centre/1/7

2-They will select a year , month and date from the given drop down options

3-Click" PLOT" to obtain the Data plot

4- Data is transferred at 5 minute intervals, 1 record per minute.

5- Students would analyze the plot to detect the variations due to slow ground level event or Forbush decrease event.

Working Note:

For slow ground level event detection (increase in count rate) and for forbush decrease (decrease in count rate) hourly averages of the minute data are used. Alert thresholds (above and below) have been set at 4 times the standard deviation obtained over a 48 hour period.

I

Activity

http://www.sws.bom.gov.au/World_Data_Centre/1/7

Cosmic Ray

Before proceeding, you can check the Cosmic Ray data availability. To view real time cosmic ray data and understand the application of cosmic ray data in space weather forecast, please see Australian Antarctic Division Cosmic Ray Real Time Data.

This data set is provided courtesy of the Australian Antarctic Division.To understand the Cosmic Ray data files, please see Cosmic Ray Data Format.

If you need more information about this data set, please use the Request Form to contact the WDC or see the FTP Download page.

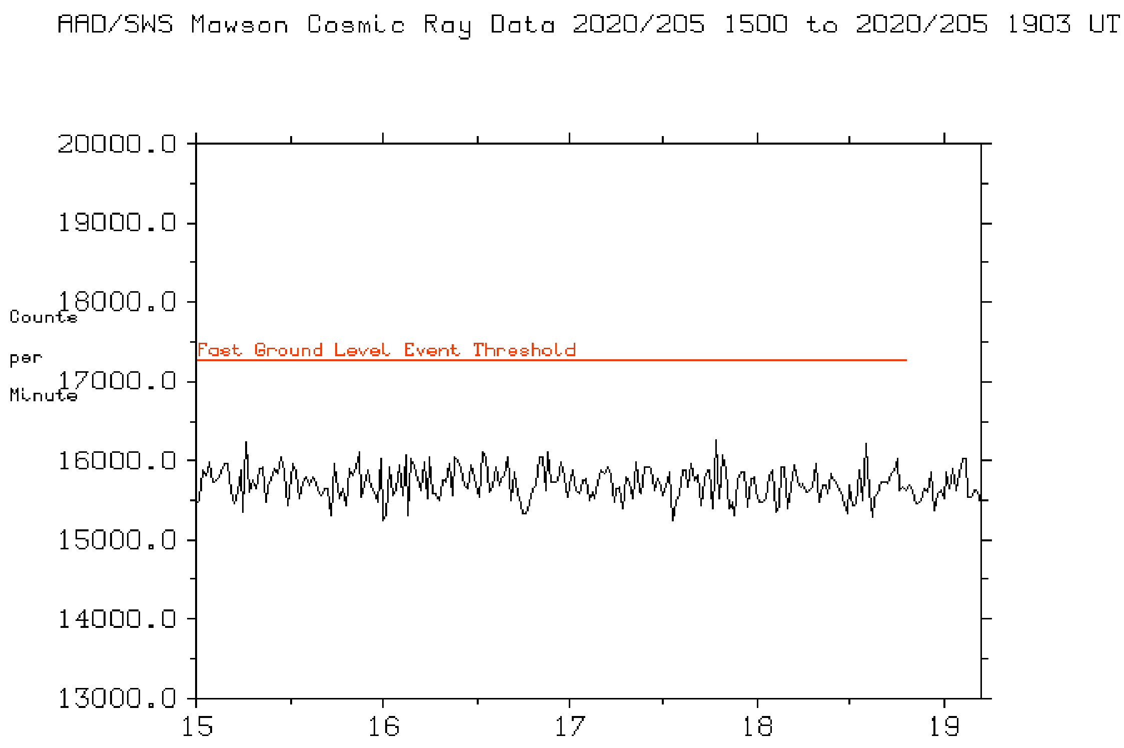
Select **Station**, **Year**, **Month**, **Day** and then click **Plot** button to display a Cosmic Ray graph.

1/5:Select a Station	2/5:Select a Year	3/5:Select a Month	4/5:Select a Day	5/5: Select an Action
Mawson Kingston	2020 2019 2018 2017 2016 2015 2014 2013 2012 2011 2010 2009	01 02 03 04 05 06 07	12 13 14 15 16 17 18 19 20 21 22 23	**You have selected:** **Station:** Mawson **Date:** 23/07/2020 Plot Download Data

EVENT DETECTION PLOT

Fast Ground Level Event Detection Plots

Latest Minute Data:



Slow Ground Level Event and Forbush Decrease Detection Plot

Hourly Averaged Data: