Fermilab Education and Public Engagement Activity Template

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Activity Name Cloud Chamber	
Grade Level **Middle-H.S**	**Unit Topic Connection** Cosmic rays, particles, Neutrino

The Hook

How do we study what we cannot see? How do we know something we cannot see exists?

4850 Feet Below-Video

Scenario/Background Information

Universe is made of many different kinds of particles. There are particles which we can see and there are particles which we cannot. If we break matter into smaller particles we get atoms and if we break them we get subatomic particles. But there are particles floating around in the universe which are produced when they interact with other particles. We cannot see these subatomic particles with naked eye. We need special experimental setup to see these particles and we are going to build a setup called a cloud chamber which will help us look at these particles called cosmic rays (mostly muons) which we couldn't see by our naked eye.

Safety

isopropyl alcohol-wear protective eyewear (eyewash present)-print MSDS
if choosing radioactive material (alpha, beta, gamma encased in chip) students can touch if encased.

Student Question/Problem/Challenge

They answer a series of questions.

what is the smallest object can you see with your naked eye?
Do you know of any objects which you cannot see from your naked eye ? eg: air
If you cannot see an object does it mean it doesn't exist ?
What are some objects that you cannot see but detect/feel ?
electrostatic demo: balloon rub it over the head and place it near small pieces of paper and what happens?
Those are electrically charged. what does it mean? There are subatomic particles called electrons which exert electric force on the paper which attracts/repel the balloon.
Add evidence that you gathered
Next we will build a special device which enables us to see some of these subatomic particles.

Learning Goals/NGSS Performance Expectations

Goal is to prove that there are particles which we cannot see but they exist and can be observed.

Practice 2 Developing and Using Models Modeling can begin in the earliest grades, with students' models progressing from concrete "pictures" and/or physical scale models (e.g., a toy car) to more abstract representations of relevant relationships in later grades, such as a diagram representing forces on a particular object in a system. (NRC Framework, 2012, p. 58)
Models include diagrams, physical replicas, mathematical representations, analogies, and computers

What will you need?

Supplies:video link to lab and supplies found here: https://www.youtube.com/watch?v=QCAVlMTBMe0 black sponge isopropyl alcohol (purer IPA better) rubber band metal container compressed air small flashlight for illumination syron wrap black construction paper-cut in circle to fit container	Setup https://www.youtube.com/watch?v=QCAVlMTBMe0 Tips can use dry ice with isopropyl alcohol

Process

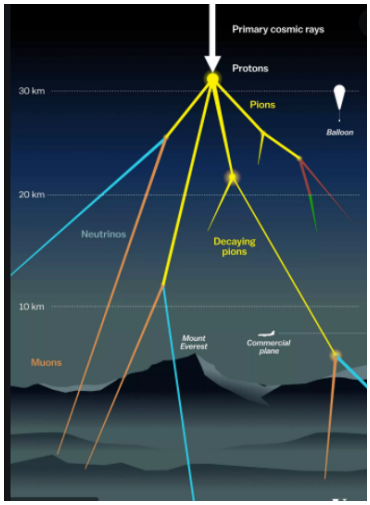
(Write a process that will **guide the facilitation** of the activity. Remember that the point of the activity is for the students to think about what **they** need to do to achieve their goals.)

- students are given the question of "How do we study what we cannot see?"
- specifically-what are particles, and how do we know they exist?
- brainstorm-share pair in person or virtually use "jamboards" in small groups- to get ideas of how to prove they exist.

- the teacher can then use the jamboard ideas to fuel discussion ultimately leading to making a cloud chamber. (if Hybrid-have one student in school be the "leader" building the device while in a breakout room with a group of students, and with video on showing, students at home guiding them to build the device)

Set up Cloud Chamber
Background information and details of the Cloud chamber:
video of set up

What are we seeing in this cloud chamber?



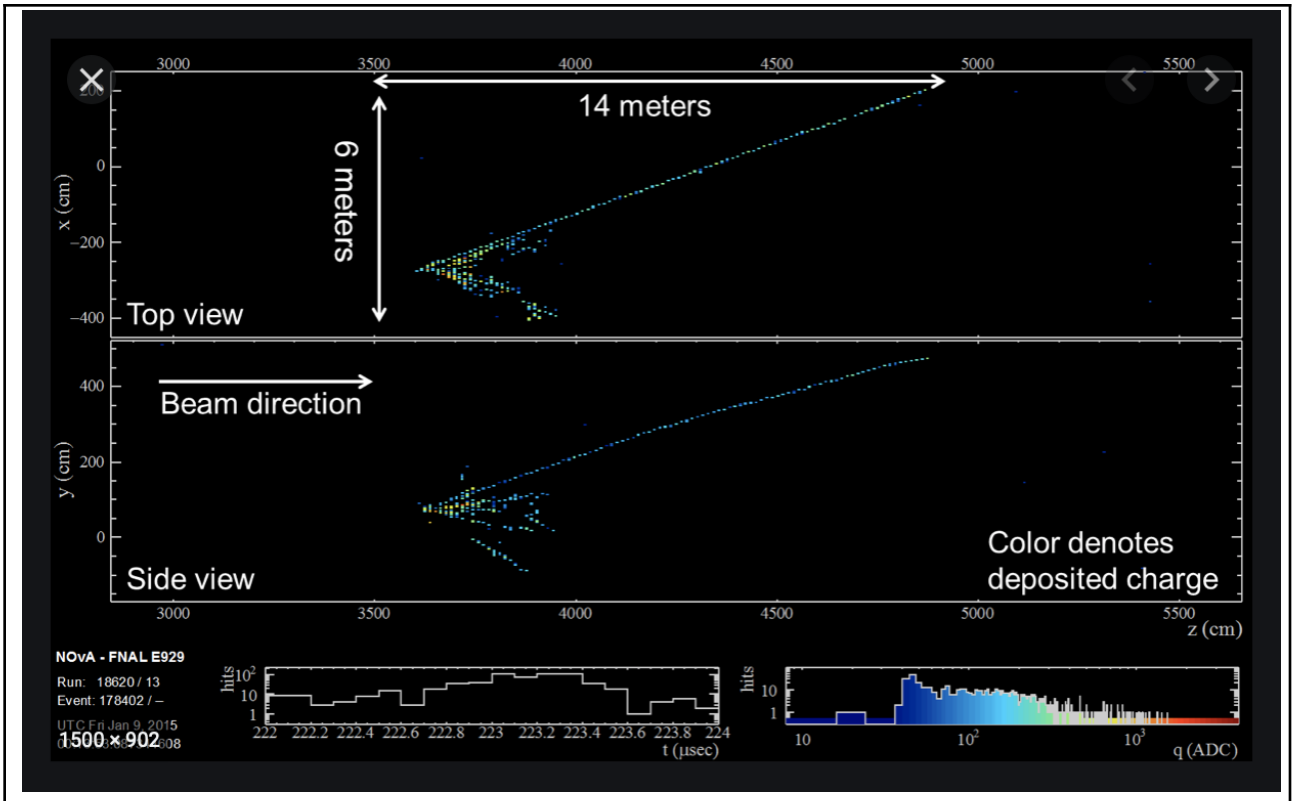
High energy particles like protons collide air particles in earth's atmosphere and produce a bunch of other particles . eg: protons collide air particles and produce pions which decay into muons which is what you see in the cloud chamber.

Which direction are the tracks ?

Now place the radioactive substance near the cloud chamber? do you see more tracks? and is the direction random now?

Now we will look at a giant version of this cloud chamber.

We will relate this to an experiment at Fermilab. This is a live event display here from experiment NoVA. More details about the experiment here
https://novaexperiment.fnal.gov
https://nusoft.fnal.gov/nova/public/
can see these particles in a giant detector.



What are some other interesting subatomic particles ?

Neutrinos !!!! which is what Fermilab tries to look at in these giant detectors. You cannot see tracks produced by neutrinos because they don't. they can only produce tracks when they interact with other particles and that produces tracks which we can see in the detector.

In the above picture you see very long track which are called muons. and by looking at the direction of muon and other particles we can find the energy and direction of neutrino hitting NOvA detector.

Neutrinos dont interact as often as other particles. They are quiet antisocial.

also talk about rutherford alpha particle experiment as an evidence to nucleus.

Wrapping it up

(Provide suggestions for classroom discussion and pacing from lesson to lesson as well as connecting to the curriculum unit topic and learning goal.)

- ★ Is this average different from the rates you observed before you installed the shielding?
- ★ If you had unlimited funds and space, how would you improve your design to make your shielding more effective?

Assessment

(This activity may serve as a performance assessment for a unit. How can the students apply their content knowledge and be aware of the many practices they utilized during the challenge activity? Provide suggestions on how to assess student success. Suggestions may include student logbooks, including notes, data and reflection on their thinking.)

Pear Deck Interactive:

They answer a series of questions.

What is the smallest object can you see with your naked eye?
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Standards Connections (Connect to learning goals/performance expectations.)

NGSS Disciplinary Core Ideas HS-PS1-8	**NGSS Science and Engineering Practices**	**NGSS Crosscutting Concepts**
CCSS Math	**CCSS ELA**	
SEL	**CTE**	
Other		

★ **Petri-dish cloud chamber from Thomas Jefferson National Accelerator Facility**

★ **Particle detector from Symmetry Magazine**

★ **Compressed air cloud chamber featured at Physicsworld.com**

Resources and References

(List any useful links for teacher background information. List student resources that may be needed.)

We are one Fermilab
https://news.fnal.gov/wp-content/uploads/2018/10/we-are-one-fermilab.jpg

How Particle Physics Discovery Works
https://www.fnal.gov/pub/science/particle-physics-101/how-works.html

Fermilab Ecology
https://ecology.fnal.gov/

NGSS - Science and Engineering Practices https://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf

Science, Technology, Engineering and Mathematics Career Cluster Knowledge and Skill Statements (2008)
https://cte.careertech.org/sites/default/files/K%26S-CareerCluster-ST-2008.pdf

CCTC - Career Ready Practices
https://cte.careertech.org/sites/default/files/CareerReadyPractices-FINAL.pdf

Project Lead the Way, Engineering Design https://www.pltw.org/our-programs/pltw-engineering-curriculum

5Es
https://ngss.sdcoe.net/Evidence-Based-Practices/5E-Model-of-Instruction

Claim, Evidence, and Reasoning

- **BSCS Scientific Explanation Tool - https://www.amnh.org/content/download/146458/2328830/file/Explanation_Tool_MASTER.pdf**
    - **Rubric https://www.amnh.org/content/download/146460/2328840/file/Explanation_Tool%20RUBRIC.pdf**
- **Scientific Argument Tool - http://sepuplhs.org/pdfs/Argument_Tool_MARCH2016.pdf**
    - **Rubric - http://www.argumentationtoolkit.org/uploads/2/1/4/1/21417276/evidence_rubric.pdf**
- **Sentence Starters for CER - http://www.thinksrsd.com/wp-content/uploads/2014/02/CER-Sentence-Starters-CER.pdf**
- **NSTA Resources on CER - https://learningcenter.nsta.org/mylibrary/collection.aspx?id=GBdqFKABr0U_E**