**Quarknet Summer 2014 Workshop**

**Lesson Plan Framework for Student Project (Altitude vs. Cosmic Ray Flux)**

**DESCRIPTION OF LESSON**

In this investigation, students will compare flux studies of data sets from the Cosmic Ray e-Lab from locations on the same date range (month) and configuration with different elevation. Students will run flux studies on at least 10 data sets. They will graphically analyze this data to find the relationship between flux and elevation.

**STANDARDS ADDRESSED**

Next Generation Science Standards:  
ESS2-1 Develop a model based on evidence to illustrate the relationships between systems or between components of a system.   
ESS1-6 Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.   
ESS1-6 Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.   
ESS2-2 Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Common Core Math Standards:

MP.2 Reason abstractly and quantitatively.

MP.4Model with mathematics.

Common Core English and Language Arts Standards:  
RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.  
WHST.9-12.1 Write arguments focused on discipline-specific content.   
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

**LEARNING OBJECTIVES**

Students will know and be able to:

* Use the Cosmic Ray e-lab to find appropriate data from multiple detectors and produce a flux study for each data set. Describe the meaning of coincidence as it applies to the geometry and collection of data with the CRMDs.
* Create and interpret a flux plot from stored Cosmic Ray e-lab data to get an average flux for each elevation point.
* Create a graph of Average Flux vs. Elevation and evaluate the
* Develop possible extension questions for further study as related to the influence of elevation on muon flux (such as latitude, weather, etc.).

**PRIOR KNOWLEDGE**Students must know how to find the elevation of various Quarknet detector locations.

Students must know how to access Quarknet data of the e-lab interface

Students must know how to generate Flux Plots using the cosmic e-lab interface

Student must know how to plot data in Excel, Logger Pro or Data Studio/Capstone

**BACKGROUND MATERIAL**

Start with the Big Picture in the Library on the Library page of Cosmic Ray e-Lab.

Use the Project map--Getting Starting: Describe cosmic rays, Investigate detectors, Analyze Data under Figure it out. In the library, there is a tutorial for a flux study.

Use Google Maps to spatial understand locations

**IMPLEMENTATION**

1. Have students read to gain basic cosmic ray background knowledge

2. Students discuss factors that affect muon flux rates (**mfr**)

3. Students predict the relationship between altitude and **mfr**

4. Students develop a set of criteria for detector site selection

5. Students gather **mfr** data and altitude data for at least 10 sites

6. Students plot data and perform statistical analysis (R2 and/or RMSE) and data trend

7. Students summarize work in a Qnet poster template

**ASSESSMENT** – answer the following in complete sentences and be sure to cite data/results

1. What is the relationship between altitude and **mfr**?

2. How confident are you in your findings – explain weaknesses and assumptions in your analysis protocol.

3. What further investigation (s) should be performed in order to better understand the variables investigated?

*If there are multiple groups working on this, facilitate a post-lab discussion using whiteboards to compare the differences and similarities between* ***mfr*** *and elevation – identifying the similarities and differences in their work.*