The Sun's Moles: How Sunspots Affect the Fall of Muons to the Surface of the Earth

Group: Muon2
Rebecca Kish
Nick Olsen
Michele Cagier
Travis Martinus
10/1/09

Nicholas Olsen

Purpose and Research Question:

The question that faced our group this week was this: how does the amount of sunspots on the sun affect the amount of muons that fall to the surface of the Earth. We thought long and hard about how we could study this and then analyze and develop the results into a recognizable format. The hypothesis that we have decided to study is that the greater the number of sunspots, the less muons that will be recorded on our sensors. This will be particularly simple to perform as NASA has announced that there is a recorded high in sun spots currently. We will compare this to the data that we will gather, and also compare past data of sun spots and muons.

Our research question is the following: How does the number of sunspots on the surface of the sun affect the number of muons that hit the surface of the earth. W The basis of our question was the fact that NASA has announced an all-time high of sunspots in history.

Travis Martinus

Research:

a. Background

Sunspots were first telescopically observed in 1610 by astronomer Thomas Harriot, however all through history references have been made to sunspots originally by Chinese astronomers in 28 B.C. The discovery of sunspots caused an upheaval, as it showed that the sun rotated and that the sun also changed, contrary to previous teachings by Aristotle.

The first astronomer who found cycles of the sunspots was Heinrich Schwabe in 1826-1843 and influenced others such as Rudolf Wolf and Joseph Henry who studied the spots. Rudolf Wolf was one of the first to make systematic observations of the spots and correlate the number of spots to how well the sun was observable. He also made a timetable of the sunspots until 1700. Joseph Henry however was the first to discover the spots were cooler then the surrounding area on the sun, by projecting the sun onto a screen and making observations.

Currently sunspots are observed and recorded by the Royal Observatory of Belgium and have been since 1991. The Royal Observatory records sunspot activity in the Sunspot Index, and recently sunspot activity has been dwindling perhaps even disappearing as some astronomers speculate.

b. What they are

Sunspots are essentially colder areas of the sun. The coldness is caused by increased magnetic activity which inhibits heat transfer on the surface (or photosphere) of the sun.

c. Significant historical events

September 1, 1859-

An extremely powerful solar flare disrupted electrical telegraphs, and caused visible “Northern Lights” (Aurora Borealis) as far south as Hawaii.

November 4, 2003-

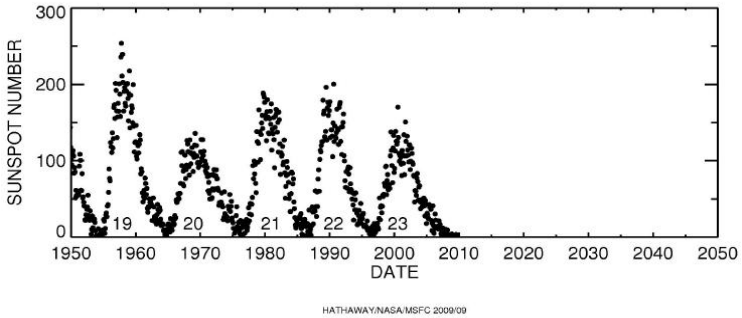
The most powerful flare observed by satellites. Lasted for eleven minutes and produced an X28 flux (extremely powerful x-ray).

Michele Cagier
Experimental Design

How do sun spots effect the fall of muons on the earth? And does the size of the spots correspond with more muons or less?

Sunspots were first discovered by telescope in late 1610 it is debatable whether is was first by Galileo Galilei or by an English astronomer named Thomas Harriot and two Frisian astronomers Johannes and David Fabricius.
Sunspots are dark spots on the surface of the Sun. They can last from several days up to several weeks. Sunspots are magnetic regions on the Sun with strengths thousands of times stronger than the Earth's magnetic field. Sunspots usually come in groups with two sets of spots. One with a positive/north magnetic fields the other with a negative/ south magnetic field. The field is strongest in the darker parts known as the umbra and weaker and more horizontal in the lighter part known as the penumbra.

The graphs below show the number of sunspots through the years...

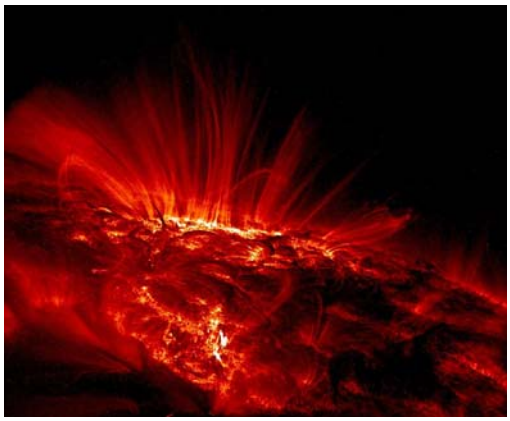


Michela Cagliero

Procedure:

1. Come up with a research question.
2. Research the topic (correlation between muons and sunspots)
3. Analyze the gathered data
4. Compare our muon data to others research on the recent sunspots.
5. See if there is any correlation between the amount of sunspots and the number of muons.
6. Discuss results and come to a conclusion.
7. Publish results.

Travis Martinus



Analysis:

a. <u>What we expect</u>

Our group predicts that the more sunspots we observe, the less muons we will have compared to when we observe less or no sunspots. This can have many reasons, such as the magnetic field that sunspots emit could disrupt the muons entering our atmosphere or even our solar system. Also Sunspots can affect our weather which also could affect how well muons pass through our atmosphere.

b. <u>How we will verify</u>

We will verify out findings by cross referencing our muon counts with the Solar Index that the Royal Observatory of Belgium regularly updates with sunspots they view. When we know the exact times of the sunspots and the muons we can see if the muon count decreased during the sunspot, and if so, then by how much and if higher voltage muons still appear or if it is the lower voltage muons that make it to Earth.

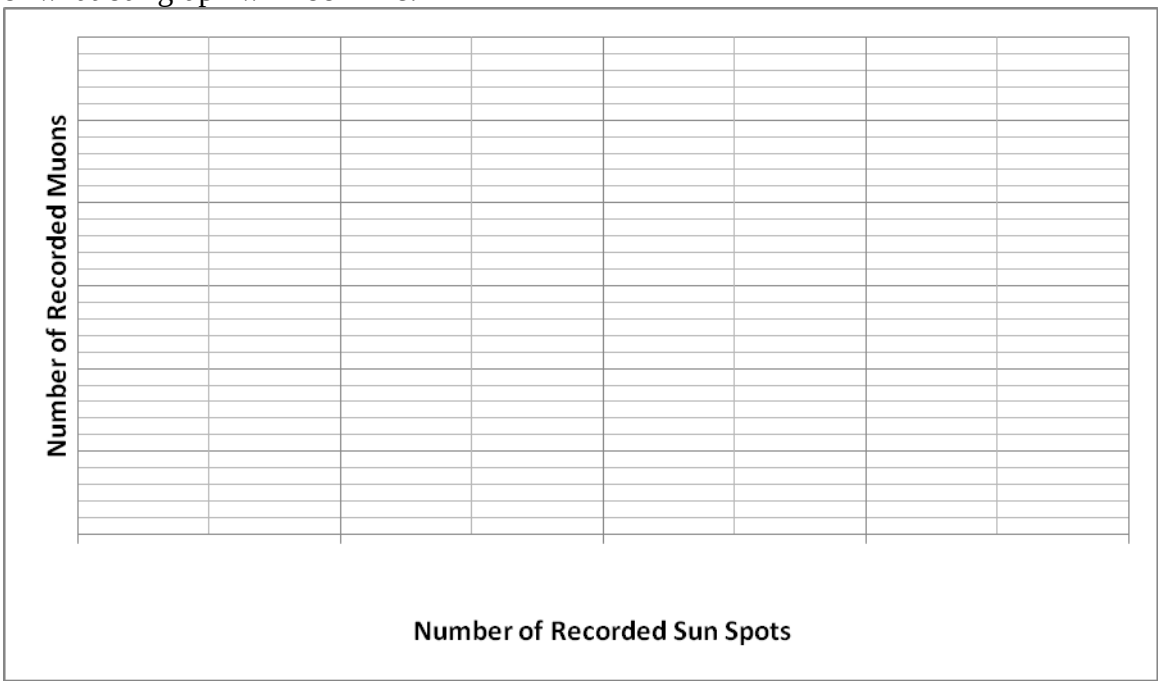
c. <u>Possible problems</u>

Some problems we might come across are; if the most days we collect data are overcast then we might not know if the change in muons is from sunspots or the overcast weather. A solution to this is to take enough data that we can have a pattern in when there is overcast weather and when there is not to compare to see if that could affect our data at all. Another issue could be if there are no sunspots during our research time; however that is improbable, as sunspots are not infrequent and happen consistently. Hopefully we will not run into these or any other problems, however if we do I am confident our group can adapt to the adversity and overcome it and answer our research question confidently with reliable data to back our findings.

Rebecca Kish

Deliverables

Our group, Muon2, has decided to research the effect of sun spots on the fall of muons to the surface of the earth. The group has hypothesized that with an increased number of sun spots; there will be a decrease in the number of muons that hit the surface. After collecting the data, we will provide a graph that illustrates the correlation between the number of sunspots and the amount of muons that are registered. Here is an example of what our graph will look like:



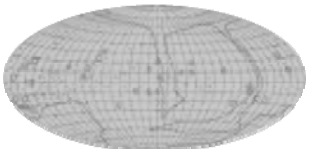
We have also chosen to create an online poster that will cover all of our research and data, and will explain our findings in detail.

Rebecca Kish

Recourses

After thinking through the project, our group has come to the conclusion that we will need the following materials in order to perform our experiment.

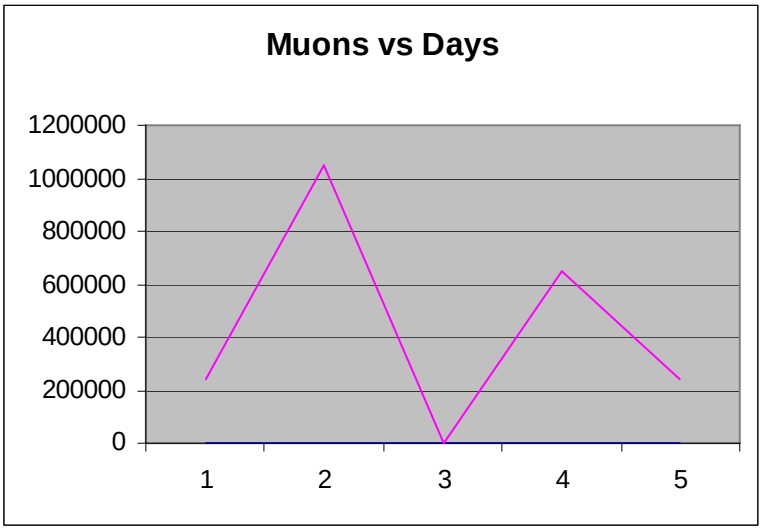
1. The muon sensor
2. A telescope capable of allowing us to observe live sunspots
3. A selected area from which we can best observe the sun spots
4. Possibly a map of the sun
5. A copy of the research team's data
6. A copy of NASA's resent studies on sun spot activity



We feel that it is possible to complete the experiment in the allotted week if everyone is responsible and does their part of the work.

Michele Cagier
Statistics and Data:

There is an expected one muon in every square centimeter in every sixty seconds. The greater number of points per sample gives a lesser uncertainty. An example of this would be if there were 100 muons: you would take the square root of that getting 10. So the uncertainty would be 100 $\pm$ 10, which is less uncertainty than just 1.



So far, there have been 0 sunspots recorded.

Nicholas Olsen

Personnel

The team make-up is simple. The members of the team are Travis Martinus, Rebecca Kish, Michele Cagier, and Nicholas Olsen. We are each responsible for an equal part of the work as assigned and approved by the group as a whole. When any one person is late in turning in their part of the work, it slows down the whole group, not to mention drops everyone's grades. We tend not to verbally rebuke our teammates; we simply use the "guilt factor" on them. They know when they have not done their share of the work, and they are quietly expected to make up for it, or they are the ones who pay the price.

Nicholas Olsen

The task assignments are fairly basic for our project. The majority of the time, Michele and Nick are in charge of reading and interpreting our data and all muon data necessary to our experiment. At the same time, Travis and Rebecca are in charge of researching and acquiring the sunspot data. For the group papers, we split up the work as we see fit, and as we think is fair to everyone. In addition, if anyone has not done their share of the work, then they will do the work that they missed in addition to whatever else is needed.

Nicholas Olsen

Our most valuable team member is our advisor: Mr. Kliewer. He is our expert on muons and the person whom we go to for help on this project.

Travis Martinus
Benefit

Justification: We are doing this experiment because by doing so we can learn more about sunspots and how powerful they are. Also we can learn if muons are affected by the magnetic fields produced by sunspots.

Legacy: This could tell us if the sunspots affect the muons at all, if they energize them more or restrict their movement. Hopefully this could be used later once we know more about sunspots to look back on and see what we had figured out before. As long as people view muons and sunspots this research can continue and more data can be assembled to further our conclusions.

Follow-On: To follow up on this project we would have to study sunspots themselves and how much they can fluctuate and affect our universe and how much they affect us. Hopefully scientists with more resources than us will see our poster and become interested in learning about the sun and continue our work.

Rebecca Kish

Timeline

Timeline of the Cosmic Ray Muon Detector Research:

Week One:

Day One:	Take the online Pre-test.
Day Two:	Begin the Online Logbook; describe at least 2 proposed research questions.
Day Three:	Online Logbook: Research and write about the following: Cosmic Rays, Cosmic Ray Studies, and Detector.
Day Four:	Write up the preliminary Research plan in which you discuss, purpose, and research, experimental design, analysis, deliverables, personnel, and resources.

Week Two:

Day Five:	Online Logbook: Research and write about the following: Collect/Upload Data, Search Parameters, and Analysis Tools.
Day Six:	Online Logbook: Research and write about the following: Data Error and Assemble Evidence.
Day Seven:	Online Logbook: Research and write about the following: Publish Results and Discuss Results.
Day Eight:	Write the Final Research Plan and write about Description, Personnel, Benefit, Resources, and Communication.

Week Three:

Day Nine:	Research Data and Begin the Poster Board.
Day Ten:	Research Data and Begin the Poster Board.
Day Eleven:	Research Data and Begin the Poster Board.
Day Twelve:	Complete the Poster Board.

Rebecca Kish:
Milestones

Research Basics

simple measurements - Notes on simple measurements

09/29/2009 11:08 I would have to agree with Nick, The SI system does make more sense. I feel that we should have a "universal" system for measurements.

09/29/2009 06:15 I think that the SI system makes more sense and is also easier to use. I wonder why we still use the English system, when the English don't even use it. Also, it should be fairly obvious that you can't measure distance with a thermometer. He he? In addition, if you don't know what instrument to use, then what are doing performing the experiments? -Nick

research question - Notes on developing a research question.

09/30/2009 12:57 michela..
1..one question could be how many muons would fall in a larger radius?
2..one more question is the more muons falling at a higher elevation??

09/30/2009 12:56 Nick Olsen: (Research Questions) Here are the two research questions that I came up with:

1) How many of the "hits" recorded in a spread are not registered as confirmed hits on stacked sensors?

2) How does the Earth's magnetic field affect the amount of Muons that reach the Earth's surface?

09/30/2009 12:55 Rebecca Kisch:
Research Questions:
1. How could the study of cosmic rays benefit the world today?

2. How can scientist measure the beneficial amount of cosmic rays entering our atmosphere?

3. How can scientists reduce the amount of comic rays to reach the perfect equilibrium in which the amount of cosmic rays will be beneficial?

09/30/2009 12:50 One research question could be: How much does overcast weather effect the penetration of the muons and why are the muons effected so?

Another question could be: How do the sun spots effect the fall of muons on the Earth and does the size of he spots correspond with more muons or less?

These are my research questions I'm sorry they are late i misunderstood the question and did a comment on all the basics.

-Travis M.

A: Get Started

cosmic rays - Description of cosmic rays in simple terms.

09/30/2009 06:49 Michela Cagliero..
Cosmic rays are made of around 90% protons, 10% helium nucleiand and under 1% electrons. Thier energy level is 10^20 eV. Cosmic rays, arent actually rays, but actually seperate particals coming from the sun and other unknown sources in outer space. The diffent types of particals show the varying sources.

09/30/2009 01:16 Nick Olsen:

Cosmic rays are actually individual particles from outer space, especially from energy sources such as suns and sources that we have not discovered at this time. They are made of mostly protons, some helium nuclei, and very little "heavy" particles like electrons. They can have a maximum energy level of 10^20 eV, which is much more powerful than the particle accelerators that we have built. Cosmic rays can be benificial in moderation, and harmful in large qauntities, but it is highly unlikly that we will experience such high levels in our lifetime.

09/30/2009 01:13 Cosmic particles are energized particles from deep space that are averaged out at 10^20 eV (electron

Volts) compared to the man-made accelerted particles that only reach 10^12 to 10^13 eVs.
-Travis M.

09/30/2009 01:08 Rebecca Kisch:

Cosmic Rays are the combination of protons, helium nuclei, and electrons. Cosmic particles arrive individually, and not in the form of a ray. They are energized particles that collide with the atmosphere breaking up into thousands of smaller particles.

cosmic ray study - Notes on what you can study about cosmic rays.

09/30/2009 08:54 Nick Olsen:

There are many things that you can study about cosmic rays. First, you can study their composition. Most muons are made up of protons, some are made of air nuclei, and very few are made of heavy particles such as electrons. Another aspect of the muon that you can study is the source. It is belived that, while a few do come from the sun, our sun is not a major source of energized protons. The majority of cosmic rays originate across the universe, in some distant star. There may also be other, as-of-yet undiscovered, sources even farther out. One of the other numerous things that you can study is the effect that the Earth's magnetic field and the sun's flux have on the path and number of muons that make it to the Earth's surface.

09/30/2009 01:26 Travis wrote the previous comment

09/30/2009 01:25 You can study the byproduct of cosmic rays when they hit our atmosphere (i.e. muons, pions) you can also try and find out where the cosmic rays come from and how they become so energized which would reveal more about our universe. Also we can find out what our universe is made out of, because when the energized particles hit ourr atmosphere they "shatter" into millions of different particles that we might not have ever seen before.

09/30/2009 01:14 Rebecca Kisch:

You could study the composition of cosmic rays. I have found out that cosmic rays are composed of protons, helium nuclei, and electrons. I personally think that they are probably made up from more elements then stated on Wikipedia. I would like to find out the exact composition of cosmic rays, and where their energy source comes from. I would also like to investigate the pros and cons of cosmic rays.

detector - Description of what the detector can do.

09/30/2009 09:28 Nick Olsen:

The detector is a complex piece of equipment that is made up of multiple parts. In sequence, the muon first hits the plastic scintillator, which is covered in black tape and aluminum foil. The aluminum foil reflects light, and the black tape helps prevent more light from leaking in. The idea is to make the scintillator "light-tight" so that no light can enter the sensors and influence the readings. When the muon passes through the scintillator, it creates a flash of light that is then detected by the photomultiplier tube (PMT). The PMT converts the flash into an electronic pulse, which is then sent to the data aquisition unit (DAQ). The DAQ in turn sends the signal to a computer, which records and sorts the information, eventually uploading it to a network of supercomputers. While it is doing that, it checks the "hits" in order to make sure that each hit is "ligitamite". A hit is conidered ligitamite only if two or more scintillators record the hit within a given time period of each other. At the same time, a GPS records the time and location of each "hit". This information is then downloaded onto the computer and is joined with the information from the DAQ.

09/30/2009 05:38 A Muon Detector is composed of many different part. Some essential parts of the Detector are a photomultiplier tube (PMT) which is connected to a scintillator, which is covered in black eletrical tape to keep out light. This set up is connected to a data acquisition board (DAQ) which acquires data (duh) when a muon passes through two of the scintillator and feeds it into a computer. The dectector can do many things, it can: count the rate of muons over a certain time, dectect muons, count how many different muons pass through a scintillator, and it can also calculate the lifetime of a muon.

-Travis M.

09/30/2009 01:26 Rebecca Kisch:

A detector, consisting of plastic scintillator(which has reflective material on it), a photomultiplier tube, data acquisition board, is the system that measures the time between the "muon signal" and the "electron signal." This data is then recorded in the computer in which you can then calculate the

lifetime of a Muon. The detector can also count the number of muons that come in over an interval to get a rate count.The detector can also count the amount of Muons that pass through a counter in a given time. Lastly it can count the number of muons that pass through an array of counters at the same time.

B: Figure it Out

collect upload data - Notes on collecting and uploading data

10/07/2009 12:55 Nick Olsen:

The data analysis is fairly simple. The first column is an indicator of how many "ticks" were recorded in a certain time period. The next eight columns are the actual data. Then the eleventh column is the date in Julians, followed by the time of day in UTC. Next is the date in real time and whether or not there is an interface between the DAQ and satellites. Then how many satellites it is interfacing with. The last column is the data error.

10/05/2009 10:51 As Rebecca said we found a website with the sunspot data, now all we need to to do is make two seperate charts, one with sunspots and the time and the other with muons and time and we will compare the two and try and see a correlation.
-Travis

10/05/2009 10:31 Rebecca Kisch:

Travis and I, found a web site stating all data on Sun Spot Activity. The data is recorded daily, which will allow us to compare Cosmic Ray activity to Sun Spot activity on specified dates.

search parameters - Notes on search parameters.

10/07/2009 01:16 Nick Olsen:

I ran the Flux Studies with several different parameters. First, I ran the Fermilab Test Array with channel one and a bin size of 600. Then I ran a study on channel two with a bin size of 600. Lastly, I ran the study with channel three and a bin size of 600. The only difference between the different channels was the data collected by the different channels.

10/06/2009 11:32 Rebecca Kisch:

Our search parameters are very broad as Travis said. We should collect as much data as possible to support our hypothesis.

10/06/2009 11:31 Our search parameters are very broad as Travis said. We should collect as much data as possible to support our hypothesis.

10/06/2009 08:35 Our search parameters is very broad, as any muons detected will be usefull to us in seeing if sunspots can affect muons.
-Travis

analysis tools - Notes on analysis tools to use

10/07/2009 01:23 Nick Olsen:

Analyzing data is fairly easy now that I understand how to run the flux study. After seeing the demonstration video, I was able to successfully run the study and found it to be rather tedious and frustrating. The process of analyzing the actual data is fairly easy when we graph the sunspots vs. the number of muons.

10/06/2009 11:36 Rebecca Kisch:

Analyzing data was fairly easy. We went through the tutorial during class which made it a lot easier to understand. As a group we should make sure what all the variables are, and make sure the units are in a measurement we understand.

...sorry i keep forgetting to put my name on my entries

10/06/2009 11:34 Analyzing data was fairly easy. We went through the tutorial during class which made it a lot easier to understand. As a group we should make sure what all the variables are, and make sure the units are

in a measurement we understand.

10/06/2009 08:29 The analysis was fairly easy to understand after i look at the tutorial and I ran a test analysis on data from 2007 from Fermilab to make sure I could do it
-Travis

data error - Notes of data error and background

10/07/2009 09:40 Nick Olsen:

Data error is a common occurence when it comes to scientific research. It is especially common in cosmic ray research, where you can niether see nor feel the rays. Thus, these studies are rendered an especially imperfect science.

10/07/2009 12:51 Michela Cagliero

Data Errors consistently are happening with scienfic research. These erros which tend to cause malfunction. To lessen the percentage error we will research more, to expand our data.

10/06/2009 11:40 REBECCA KISCH:

Data Errors are a common problem, in doing scienfic research. To prevent errors we will need more then the usual amount of research so we have more data to closely anazlyze.

10/06/2009 08:38 Travis wrote the previous comment again :/

10/06/2009 08:38 Data errors can happen all the time, as background signals can intermingle and cause the detector to malfunction. That is why we have such a sheer amount of data, so our percent error can be reduced to a reasonable amount.

C: Tell Others

assemble evidence - Evidence for our results

10/07/2009 10:00 Nick Olsen:

We have not been able to gather enogh evidence to be able to come to a valid conclusion. However, it can be said that some useful plots to include in our published results would be of sunspots vs muons.

10/07/2009 12:57 Michela Cagliero

We havent gathered any evidence so far, so we cannot put together our plots display them in our logbook. We will soon acquire data then starting to make graphs on sunspots and muons.

10/06/2009 11:38 As Travis said, We are unable to assemble evidence because we haven't started research. When we begin to do our research, we will easily be able to plot the data and graph it.

Rebecca Kisch

10/06/2009 08:41 As we have no evidence yet we cannot put plots into the logbook, however soon we will begin to assemble graphs on sunspots as well as muons to compare and publish them.
-Travis

publish results - Notes on publishing our poster

10/08/2009 01:18 rebecca kisch:
Our data and analysis of our Data will published on a poster. It will then get transferred onto an online poster which will be accessable to the public. In our poster we will include our data, analysis, conclusions and supporting evidence of what we found.

10/08/2009 01:17 Our data and analysis of our Data will published on a poster. It will then get transferred onto an online poster which will be accessable to the public. In our poster we will include our data, analysis, conclusions and supporting evidence of what we found.

10/08/2009 12:07 Travis:

Once we reach a conclusion we must publish our results on a poster online which will outline our findinds and conclusions with supporting evidence

10/07/2009 10:08 Nick Olsen:

Our data woud be be presented mainly in an online poster format, but with one printed packet for Mr. Kiewer. Our poster would include an abstract that describes the purpose of our project, followed by a description of our procedures that detaild the process that we went through to get our data and conclusions. Next woud be an entry for our results and analysis. Finally, the last section would be one that detailed our conclusions and discussions for the project in general.

10/07/2009 06:56 Michela Cagliero

Scientific results can be published in print with in aricles or now online wiht posters. Our poster would demonstrate: first an abstract which is "Is there a corrilation with the number of sunspots with the amount of muons?".
The procedure which is collecting our muon data and comparing it to the current sunspots. The results, which we have not obtained yet and then the discussions and conclusion.

discuss results - Notes on discussing posters

10/08/2009 01:20 Rebecca Kisch;

When we public our poster it will be accessable to the public in which people can comment and make suggestions to perhaps better our results.We are also able to view the work of others, in which we can learn how other people worked and apply it to our research.

10/08/2009 12:10 Travis:

Once we publish our poster other students or scientists can comment our work and we can discuss with them what we did. We can also comment on other peoples work and discuss with them. Hopefully we will have many discussions with other students and teachers and hopefully professors and scientists as ell.

10/07/2009 10:21 Nick Olsen:

Disscusion is when scientists communicate back and forth with each other in order to verify certain experiments done by other scientists. Most discussions on our level occur when others comment on our published poster and when we comment on other posted posters. We have as yet been unable to discuss our results as we have none to discuss. However, we expect to be able to be able to conduct several intelligent disussions with students from around the U.S.

10/07/2009 07:02 Michela Cagliero

Disscussion occurs when you publish your results and other are able to comment or give feed back. This way you can make sure your data was gathered correctly and are able improve research and analysis. We cannot yet do this because our results are not quite yet obtained.