AMS-02 ACTIVITY

Study Cosmic Rays with Neutron Monitors

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AMS

Exploring Cosmic Ray Properties

In this tutorial you will learn about cosmic ray properties as measured by neutron monitors (NMs). With this knowledge we can design a measurement to undertake with our particle detector this week.

I.   Exploring the Neutron Monitor Database

There is a worldwide network of NMs that are used by scientists to monitor cosmic rays. We can used this network to measure a number of known cosmic ray properties and make predictions about what we can measure with our particle detector.

1. Explore the map of NM stations, and select 5 or 6 with a wide range of properties such as locations, altitudes, cutoff, and 4 letter nickname.
   http://www.nmdb.eu/nest/help.php#helpstations

Stations List

(click on the stations to get more informations)

Emilio Segre Obs. Israel ✕
Coord: 33.3, 35.8
Alt: 2055 m
Cutoff: 10.75 GV

New stations: Some new registered stations do not show in the form because they are not sending data yet.
Stations colors: Some stations have the same grey color: these are new stations (in NMDB) which are under test. Using the form, just click on the color box next to the station name to change this station color*
You can also apply the same color to all stations (one color button) or reset all colors (reset colors).
All/online stations : Check all stations with the "all stations" checkbox, or select only the stations which are online (i.e. with a lag lower than 15 minutes)

AATB = Alma-Ata B (R=6.69, Alt=3340 m)   MCMU = Mc Murdo (R=0.30, Alt=48 m)
AHMD = Ahmedabad (R=15.94, Alt=50 m)   MCRL = Mobile Cosmic Ray Laboratory (R=2.46, Alt=200 m)
APTY = Apatity (R=0.65, Alt=181 m)   MGDN = Magadan (R=2.10, Alt=220 m)
ARNM = Aragats (R=7.10, Alt=3200 m)   MOSC = Moscow (R=2.43, Alt=200 m)
ATHN = Athens (R=8.53, Alt=260 m)   MRNY = Mirny (R=0.03, Alt=30 m)

2. Make a log of the stations you are interested in getting data from, and include their relevant details:

_____

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What trends do you see between the locations and the cut off rigidities?

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3. Go to http://www.nmdb.eu/nest/ select one of the stations you identified above

Is your choice of NM online? _____

Make a plot of the station data over the last week. In the Date Selection panel choose Last and use the drop down selector to pick 7 and select the days button.

At this point we will not be changing the time Resolution, and the Output should be set to plot. However, it will be up to you to decide which of data variables and scale options you select.

Make a plot using the overplot main panel to select all the data variables options using one of the scale options. (Make sure to click submit to view the data).

Describe what differences you see between the different Data Variables:

_____

_____

_____

Now go back and make the same overplot selections, but for one of the other choice of scale options, and describe what you see:

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_____

_____

Now when we download the data in the next section think about what options for data variables and scale you will use and why? _____

_____

_____

4. Let's look at a different time period, and see if there are any features in a larger dataset.

Pick two NMs and log them here _____

Plot the data for the month of your birth for these two NMs by changing the parameters in the Date Selection panel.
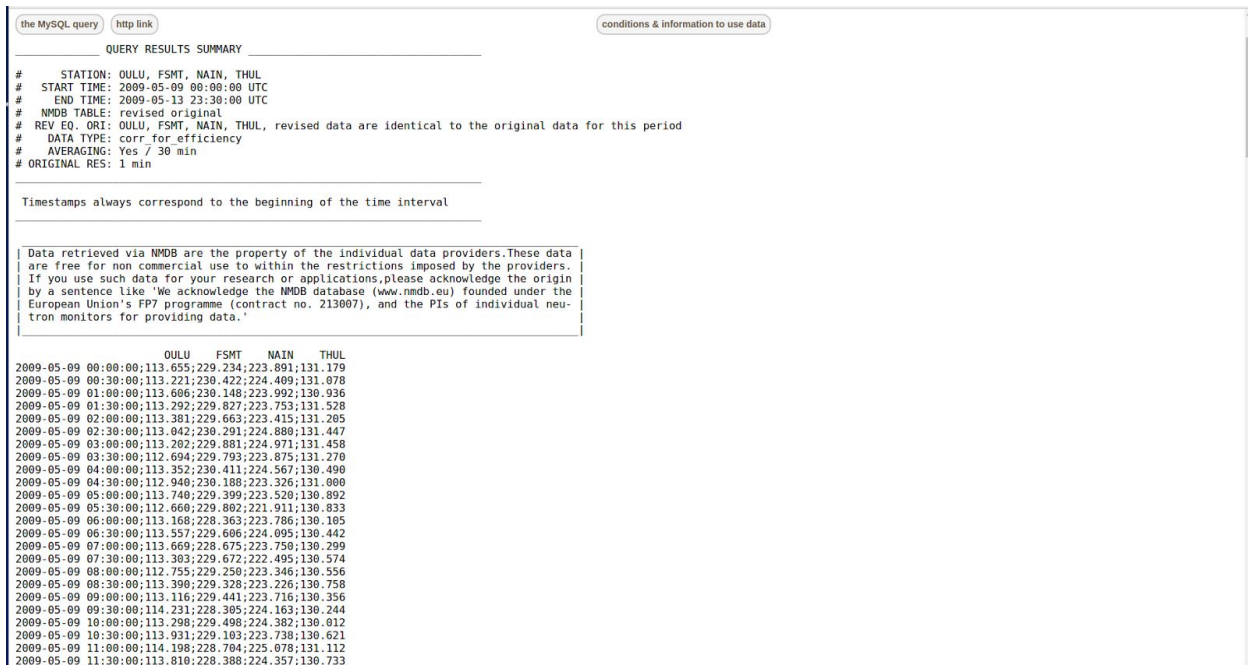
If one of the NMs is missing what could that mean?

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II.   Downloading Data to Work With

To use data in a spreadsheet, we need to retrieve the data itself instead of having the nmdb.eu website output a plot.

1. Use the date selection to select the time period from February 9, 2009 to February 13, 2009.
    a. Choose 2 or 3 NMs that have data in 2009
    b. Set the time resolution to 30 minutes
    c. Set the scale to be counts/s
    d. Set the output to be Ascii
    This will give something like this:

```
 the MySQL query   http link                                                    conditions & information to use data

                QUERY RESULTS SUMMARY _____
 #        STATION: OULU, FSMT, NAIN, THUL
 #     START TIME: 2009-05-09 00:00:00 UTC
 #       END TIME: 2009-05-13 23:30:00 UTC
 #     NMDB TABLE: revised original
 #   REV EQ. ORI: OULU, FSMT, NAIN, THUL, revised data are identical to the original data for this period
 #      DATA TYPE: corr_for_efficiency
 #      AVERAGING: Yes / 30 min
 # ORIGINAL RES: 1 min

  Timestamps always correspond to the beginning of the time interval


 | Data retrieved via NMDB are the property of the individual data providers.These data |
 | are free for non commercial use to within the restrictions imposed by the providers. |
 | If you use such data for your research or applications,please acknowledge the origin |
 | by a sentence like 'We acknowledge the NMDB database (www.nmdb.eu) founded under the |
 | European Union's FP7 programme (contract no. 213007), and the PIs of individual neu- |
 | tron monitors for providing data.'

                       OULU    FSMT    NAIN    THUL
 2009-05-09 00:00:00;113.655;229.234;223.891;131.179
 2009-05-09 00:30:00;113.221;230.422;224.409;131.078
 2009-05-09 01:00:00;113.606;230.148;223.992;130.936
 2009-05-09 01:30:00;113.292;229.827;223.753;131.528
 2009-05-09 02:00:00;113.381;229.663;223.415;131.205
 2009-05-09 02:30:00;113.042;230.291;224.880;131.447
 2009-05-09 03:00:00;113.202;229.881;224.971;131.458
 2009-05-09 03:30:00;112.694;229.793;223.875;131.270
 2009-05-09 04:00:00;113.352;230.411;224.567;130.490
 2009-05-09 04:30:00;112.940;230.188;223.326;131.000
 2009-05-09 05:00:00;113.740;229.399;223.520;130.892
 2009-05-09 05:30:00;112.660;229.802;221.911;130.833
 2009-05-09 06:00:00;113.168;228.363;223.786;130.105
 2009-05-09 06:30:00;113.557;229.606;224.095;130.442
 2009-05-09 07:00:00;113.669;228.675;223.750;130.299
 2009-05-09 07:30:00;113.303;229.672;222.495;130.574
 2009-05-09 08:00:00;112.755;229.250;223.346;130.556
 2009-05-09 08:30:00;113.390;229.328;223.226;130.758
 2009-05-09 09:00:00;113.116;229.441;223.716;130.356
 2009-05-09 09:30:00;114.231;228.305;224.163;130.244
 2009-05-09 10:00:00;113.298;229.498;224.382;130.012
 2009-05-09 10:30:00;113.931;229.103;223.738;130.621
 2009-05-09 11:00:00;114.198;228.704;225.078;131.112
 2009-05-09 11:30:00;113.810;228.388;224.357;130.733
```
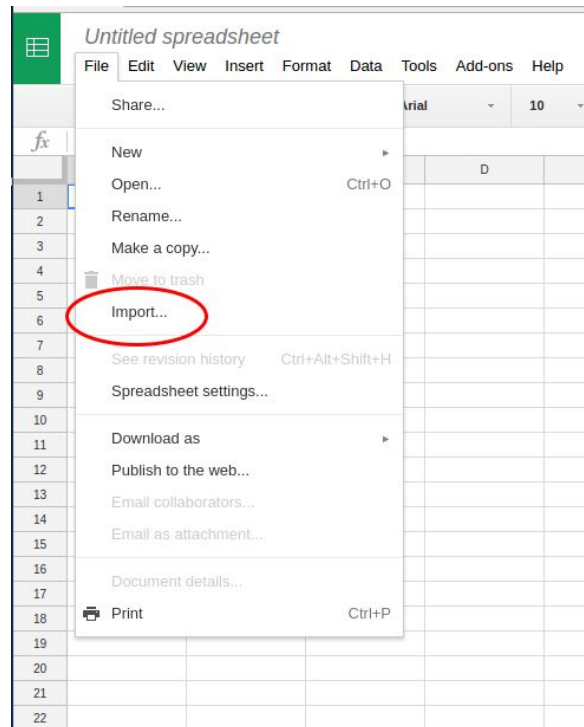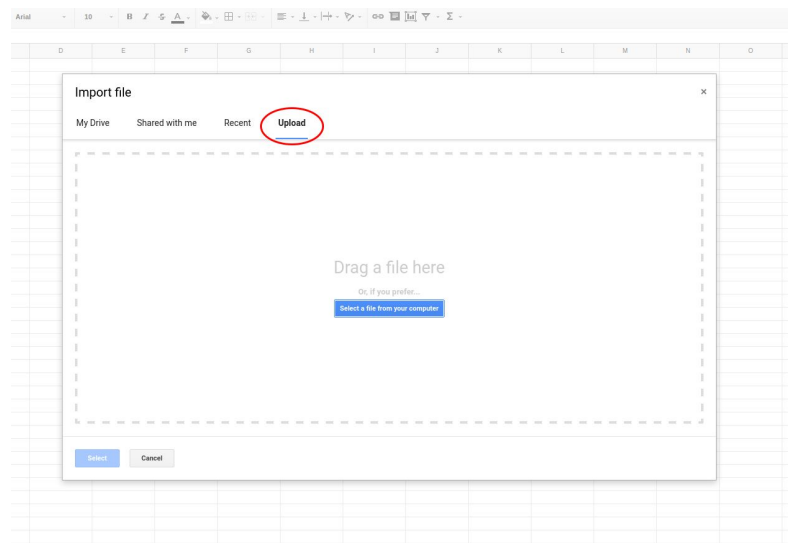
2. Select all of the text (Ctrl+a) and copy it (Ctrl+c)
3. Then paste the text (Ctrl+v) into a plain text editor (like notepad, or Text Editor) and save that file as a .txt file (filename.txt).
4. Now you can use Google sheets to import that data.
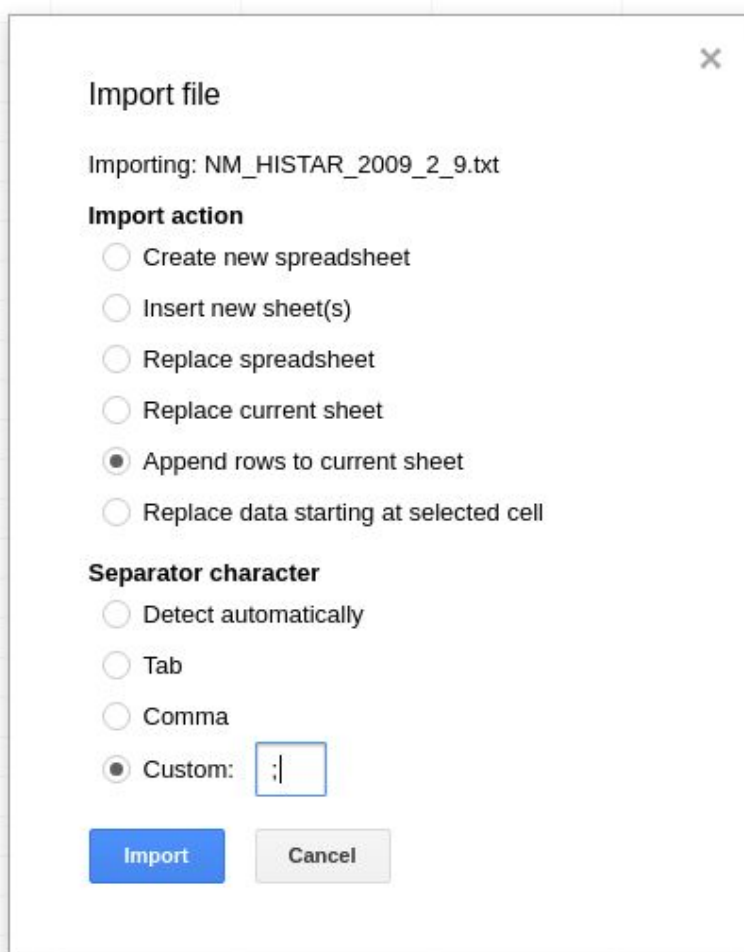   a. Open a new spreadsheet in Google Sheets
    b. select File→ Import

c. Select upload

d. Drag your .txt file into the box, or use the blue button in the middle to find it on your computer

e. Select "Append rows to current sheet" and for Separator character select "Custom" and enter ;

Import file

Importing: NM_HISTAR_2009_2_9.txt

Import action
  ○ Create new spreadsheet
  ○ Insert new sheet(s)
  ○ Replace spreadsheet
  ○ Replace current sheet
  ● Append rows to current sheet
  ○ Replace data starting at selected cell

Separator character
  ○ Detect automatically
  ○ Tab
  ○ Comma
  ● Custom: [;]

  [Import] [Cancel]

f. You should have a spreadsheet with times in the first column and NM counts/s in the columns after, with a bunch of extra stuff at the top.

g. Enter the NM names above the appropriate columns and delete the rows above the column names

III. Make Plots and Identify Trends
1. Now in the spreadsheet we can make plots of the data.
   a. In google sheets, I can do this by clicking the "Insert chart" icon and selecting an area for the data.
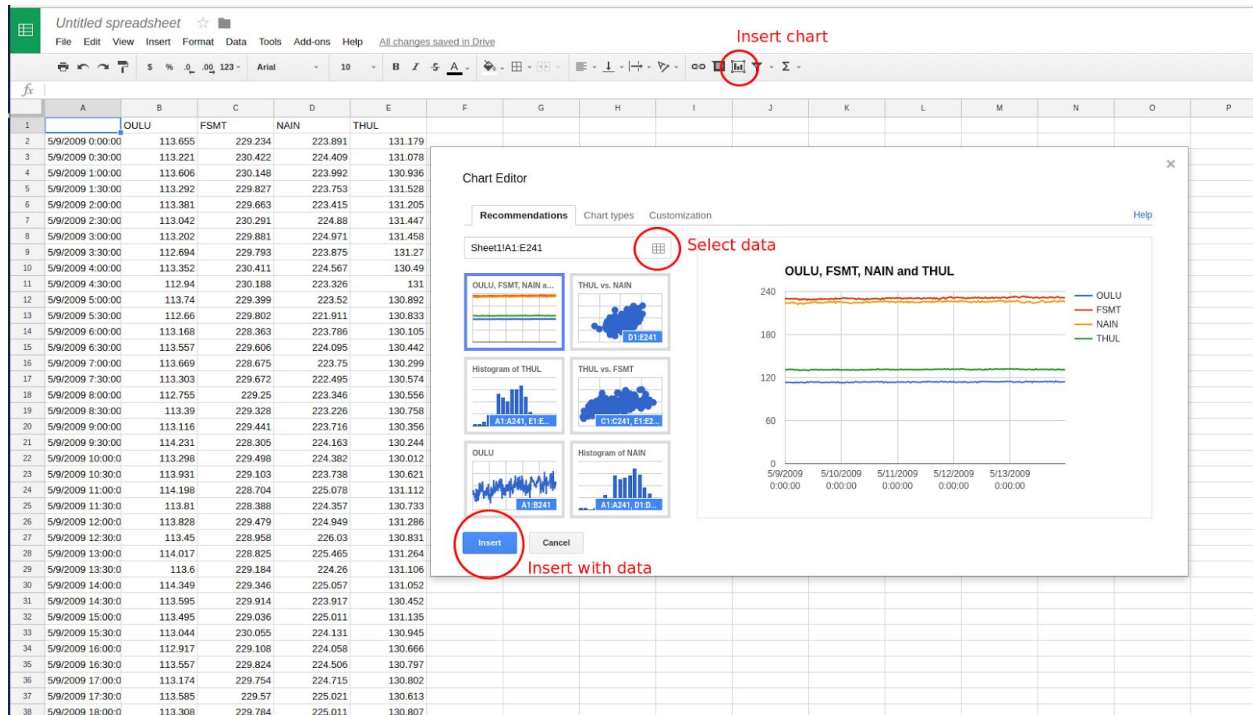
   b. Now you should have a plot of your data
      i. You can select the plot and select "advanced edit" from the dropdown box to customize your plot.
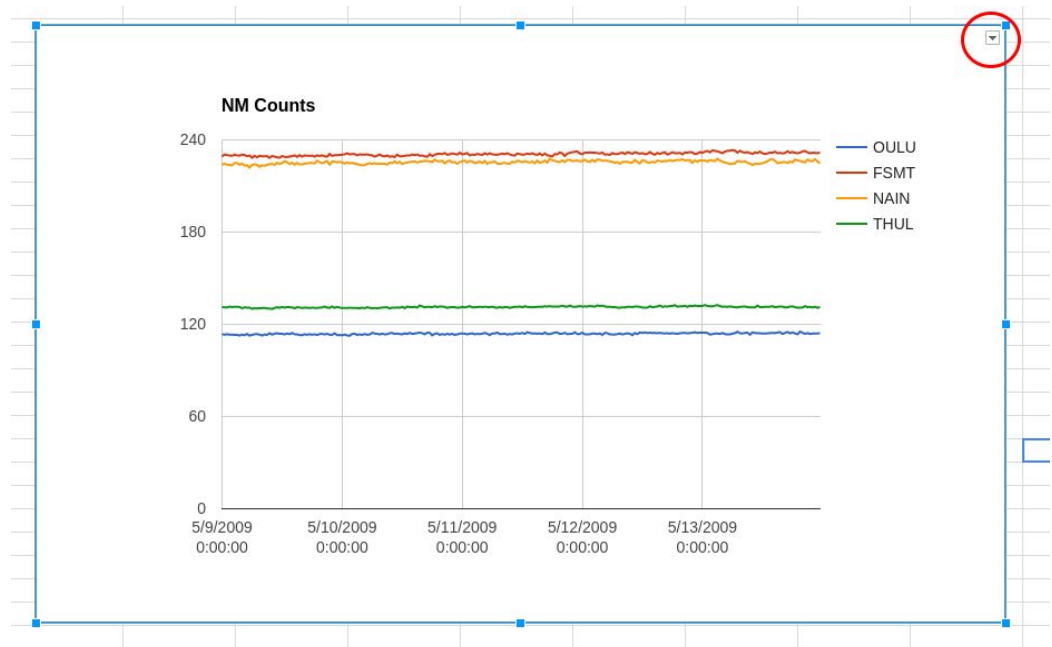
c. For this data, we will most often want to make a line plot with time on the x-axis and counts/s on the y-axis, but there are many different plots you can make to look for interesting trends in your data.

What things stand out to you about this data when you use various different plots?

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2. Looking for a trend

    a. First, create a table for just one NM by selecting for the data range column A, then clicking "add another range" and adding only the column for one NM's counts/s.

    b. Do you see any trends in the data?

_____

_____

_____

c. Now make a running average of the data
   i. Add a column next to the counts/s of a NM
   ii. Starting with the 7th point, average the points starting 6 points before and ending 6 points after the selected point
      1. Type "=average( )", and select the range of data to average inside the parenthesis

fx | =average(B2:B14)

	A	B	C	D
1		OULU	Oulu Avg	FSMT
2	5/9/2009 0:00:00	113.655		229.2
3	5/9/2009 0:30:00	113.221		230.4
4	5/9/2009 1:00:00	113.606		230.1
5	5/9/2009 1:30:00	113.292		229.8
6	5/9/2009 2:00:00	113.381		229.6
7	5/9/2009 2:30:00	113.042	113.2271538 ×	230.2
8	5/9/2009 3:00:00	113.202	=average(B2:B14)	229.8
9	5/9/2009 3:30:00	112.694		229.7
10	5/9/2009 4:00:00	113.352		230.4
11	5/9/2009 4:30:00	112.94		230.1
12	5/9/2009 5:00:00	113.74		229.3
13	5/9/2009 5:30:00	112.66		229.8
14	5/9/2009 6:00:00	113.168		228.3
15	5/9/2009 6:30:00	113.557		229.6
16	5/9/2009 7:00:00	113.669		228.6
17	5/9/2009 7:30:00	113.303		229.6

   iii. Now you can double click, or drag click and drag, the small square in the corner of your calculation box to do it for all of the data below (make sure you end calculating 6 points before the end of the data)

=average(B2:B14)

|	A	B	C	
1		OULU	Oulu Avg	FSMT
2	5/9/2009 0:00:00	113.655		
3	5/9/2009 0:30:00	113.221		
4	5/9/2009 1:00:00	113.606		
5	5/9/2009 1:30:00	113.292		
6	5/9/2009 2:00:00	113.381		
7	5/9/2009 2:30:00	113.042		
8	5/9/2009 3:00:00	113.202	113.2271528	
9	5/9/2009 3:30:00	112.694		
10	5/9/2009 4:00:00	113.352		
11	5/9/2009 4:30:00	112.94		
12	5/9/2009 5:00:00	113.74		

218	5/13/2009 12:00:	114.04	114.2439231	231.28
219	5/13/2009 12:30:	113.959	114.2752308	230.824
220	5/13/2009 13:00:	114.193	114.3102308	231.213
221	5/13/2009 13:30:	114.302	114.2869231	231.733
222	5/13/2009 14:00:	114.359	114.3376154	231.58
223	5/13/2009 14:30:	114.282	114.3296154	232.296
224	5/13/2009 15:00:	114.664	114.3728462	231.316
225	5/13/2009 15:30:	114.971	114.3745385	231.581
226	5/13/2009 16:00:	113.731	114.3426154	231.267
227	5/13/2009 16:30:	114.424	114.4208462	231.422
228	5/13/2009 17:00:	115.046	114.4404615	232.58
229	5/13/2009 17:30:	114.113	114.3974615	231.614
230	5/13/2009 18:00:	114.763	114.4017692	232.166
231	5/13/2009 18:30:	114.062	114.3300769	231.556
232	5/13/2009 19:00:	113.544	114.253	231.367
233	5/13/2009 19:30:	115.21	114.2730769	231.711
234	5/13/2009 20:00:	114.557	114.2454615	232.498
235	5/13/2009 20:30:	113.8	114.1918462	232.749
236	5/13/2009 21:00:	114.338		231.849
237	5/13/2009 21:30:	113.732		231.294
238	5/13/2009 22:00:	113.969		231.647
239	5/13/2009 22:30:	113.992		231.57
240	5/13/2009 23:00:	114.065		231.328
241	5/13/2009 23:30:	114.349		231.868
242				

iv. Now add to your plot a line for the averaged data
   1. Use "Advanced edit", go to "chart type", then add to the data range the column with your averages
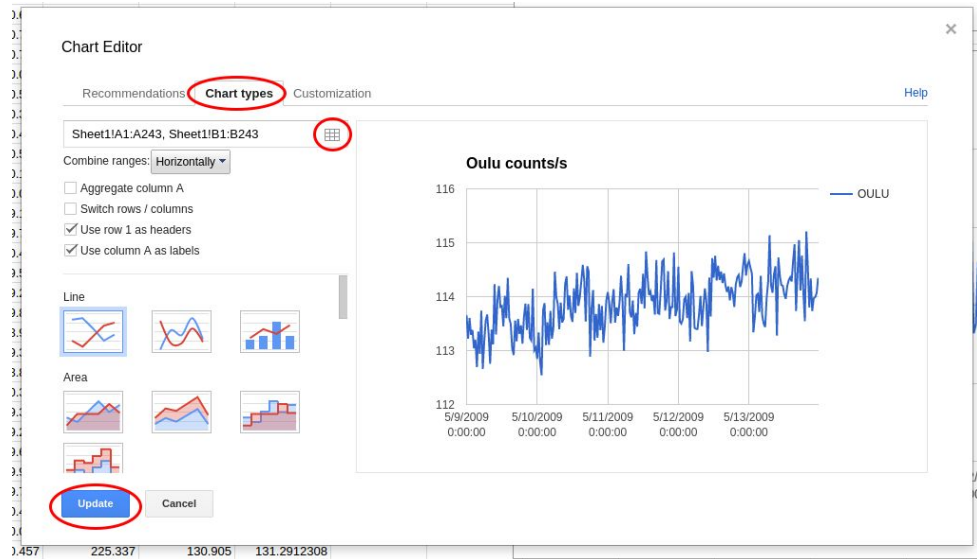
   2. Now you have a plot with the NM counts/s and the counts/s averaged over 6 hours. The averaged line is a bit smoother and can make it easier to spot trends.
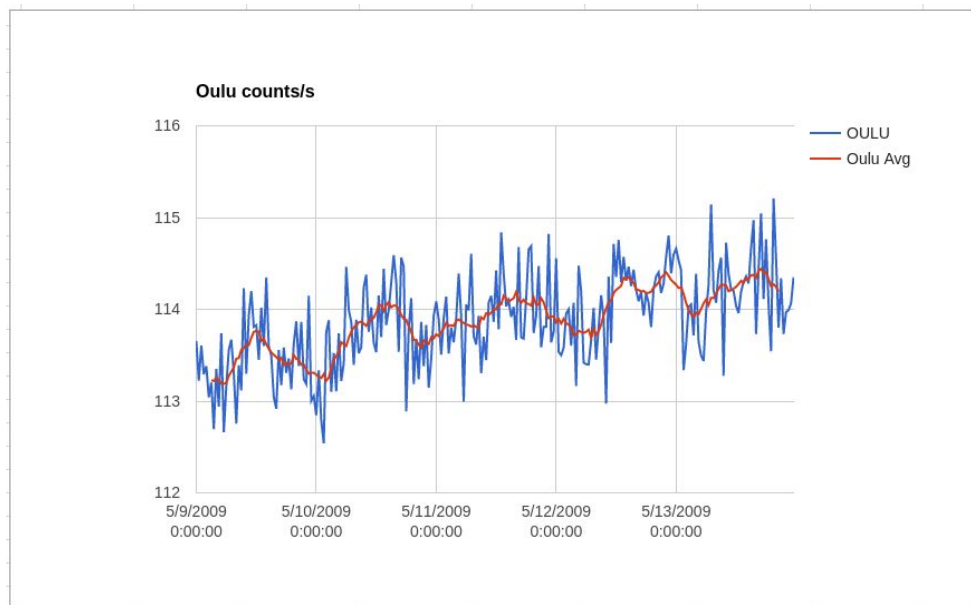
   3. Do you see any trends in the averaged line?

_____

_____

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_____

IV.   Now look for notable features in March 2012

Download the data for the month of March 2012 and put into a new spreadsheet as described above. Make a plot for counts/s v time. Make sure to log what NM you are looking at the data from. A good practice is to log your work both on paper, and in the spreadsheet so that other people can tell what is being saved.

Describe what you see:
_____
_____
_____

The large feature in March 2012 is called a Forbush decrease. Use the online plot tool to look over other time ranges to find a similar event in the same NM:

_____

What properties of cosmic rays are you most interested in examining with our "homemade" particle detector? What things can we do this week and what can we look for on longer time scales?

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