



AMS-02 ACTIVITY

Study Cosmic Rays with Neutron Monitors

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physics stuff on our website!
bit.ly/amshawaii-outreach



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 use 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>

← → ↻ www.nmdb.eu/nest/help.php#helpstations ☆

Stations List

(click on the stations to get more informations)

Map Satellite

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

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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:

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

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

The screenshot shows the nmdb.eu/nest/ web interface. The main section is titled "Stations" and contains a grid of station codes with checkboxes. The stations are arranged in five columns: AATB, CALG, ESOI, IRK3, KERG, MGDN, NAIN, NVBK, ROME, THUL, APTY, CALM, FSMT, IRKT, KIEL, MOSC, NANM, OULU, SNAE, TIBT, ARNM, DOMB, HRMS, JBGO, KIEL2, PSNM, TXBY, ATHN, DOMC, INVK, JUNG, LMKS, MWSN, PTFM, SOPO, YKTK, BKSJ, DRBS, IRK2, JUNG1, MCRL, MXCO, NRLK, PWNK, TERA. A note says "Online* stations in green". Below the grid are sections for "Closed Stations*", "Bonner Spheres*", and "Smart Selection". To the right of the station grid is a sidebar with expandable sections: "NMDB tables", "Overplot main", "Overplot Kp / Ri", "GOES proton plot", "Env. & meta data", "Scaling Options", "Event Options", "Ascii Options", and "Style Options". Below the sidebar is a "Contact: questions@nmdb.eu" link. The "Date Selection (UTC)" section has radio buttons for "Last 7 days", "hours", and "mins", and a "From" date of "1 Jun 1988" and a "To" date of "31 Jun 1988". The "Resolution" section has a "Time resolution:" dropdown set to "1 hour" and a "Smooth window:" input set to "0". The "Data variables" section has radio buttons for "Pressure & efficiency corr.", "Pressure corrected", "Uncorrected", and "Pressure". The "Scale" section has radio buttons for "Relative scale", "Counts/s*", and "Log scale". The "Output" section has radio buttons for "Plot", "Ascii", and "Plot & ascii". At the bottom are "Submit" and "Reset" buttons. Footnotes at the bottom left state: "* online means some data (realtime or not) have been uploaded during the last 15mn", "** force parameter: Read note 1 and note 3 of the help file", and "*** Table format here."

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).

The screenshot shows the NMDB.eu website interface for configuring a data plot. The browser address bar shows www.nmdb.eu/nest/. The interface is divided into several panels:

- Stations**: A grid of station codes with checkboxes. Some are checked (e.g., ROME, OULU, TIBT). A note says "(When selecting multiple stations, note that only one variable can be plotted)".
- Date Selection (UTC)**: Includes "Last" (7 days), "From" (1 Jun 1988), "To" (31 Jun 1988), and "GLE number/date" (71 (2012-05-17)).
- Resolution**: "Time resolution" is set to "1 hour". "Smooth window" is set to "0".
- Data variables**: "Pressure & efficiency corr." is selected.
- Scale**: "Relative scale" is selected.
- Output**: "Plot" is selected.
- Overplot main**: This panel is circled in red. It contains options for "optional / select only 1 station": "Corrected for efficiency", "Corrected for pressure", "Uncorrected", and "Pressure_mbar".
- NMDB tables**: A panel with a red circle around it.
- GOES proton plot**: A panel with a red circle around it.
- Env. & meta data**: A panel with a red circle around it.
- Scaling Options**: A panel with a red circle around it.
- Event Options**: A panel with a red circle around it.
- Ascii Options**: A panel with a red circle around it.
- Style Options**: A panel with a red circle around it.

At the bottom, there are "Submit" and "Reset" buttons. A footer note says: "* online means some data (realtime or not) have been uploaded during the last 15mn".

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:

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.

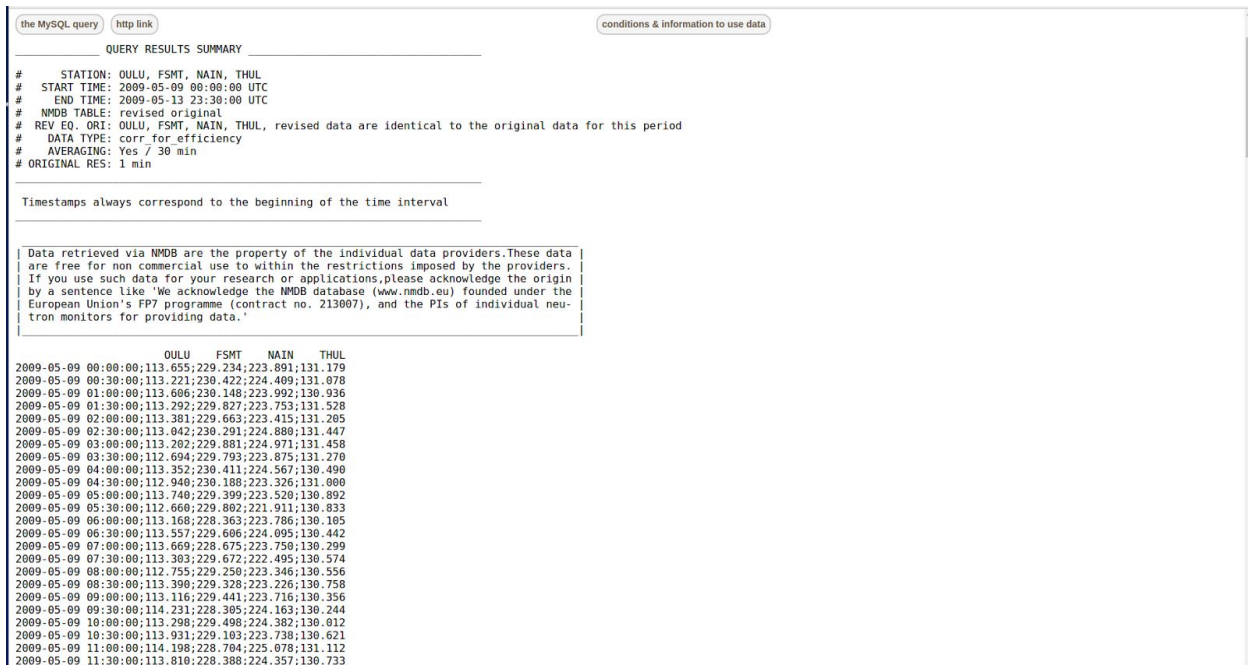
If one of the NMs is missing what could that mean?

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 screenshot shows the NMDB website interface. At the top, there are tabs for 'the MySQL query' and 'http link'. Below these is a 'QUERY RESULTS SUMMARY' section. The summary includes the following information:

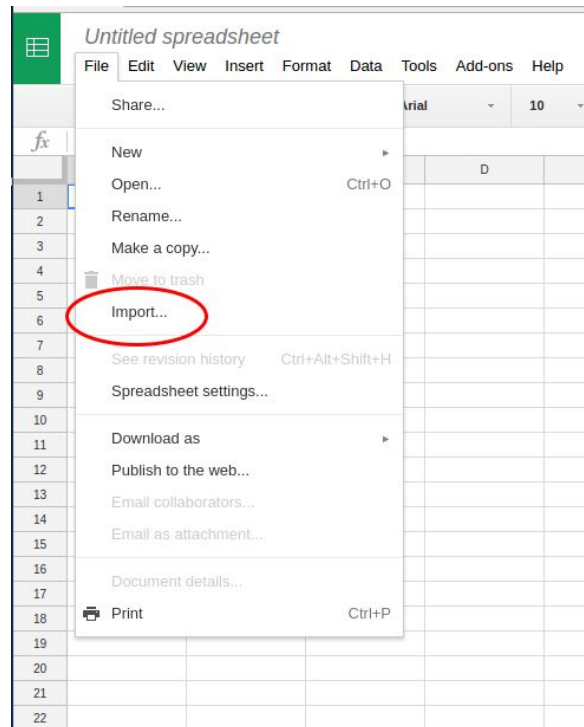
- # STATION: OULU, FSMT, NAIN, THUL
- # START TIME: 2009-05-09 00:00:00 UTC
- # END TIME: 2009-05-13 23:30:00 UTC
- # NMDB TABLE: revised original
- # REV EQ. ORI: OULU, FSMT, NAIN, THUL, revised data are identical to the original data for this period
- # DATA TYPE: corr. for efficiency
- # AVERAGING: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

Below the summary, there is a note: 'Timestamps always correspond to the beginning of the time interval'. A disclaimer box states: '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 neutron monitors for providing data.''

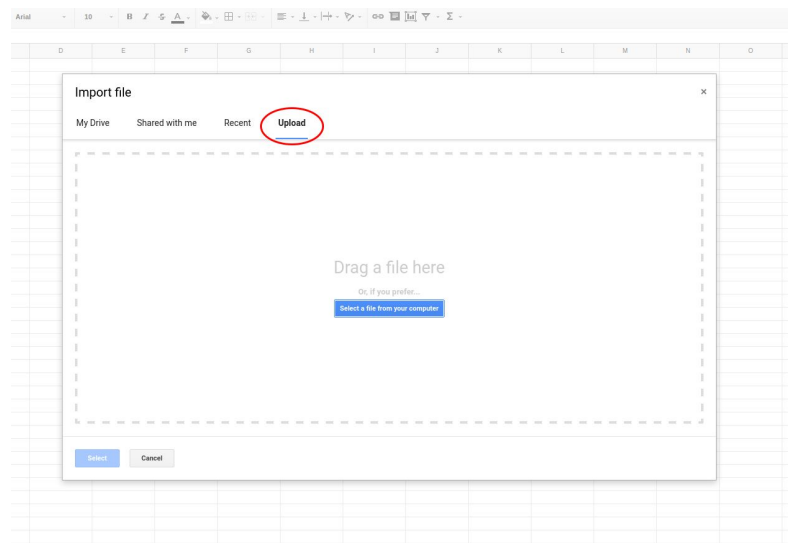
The main data table has the following structure:

	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

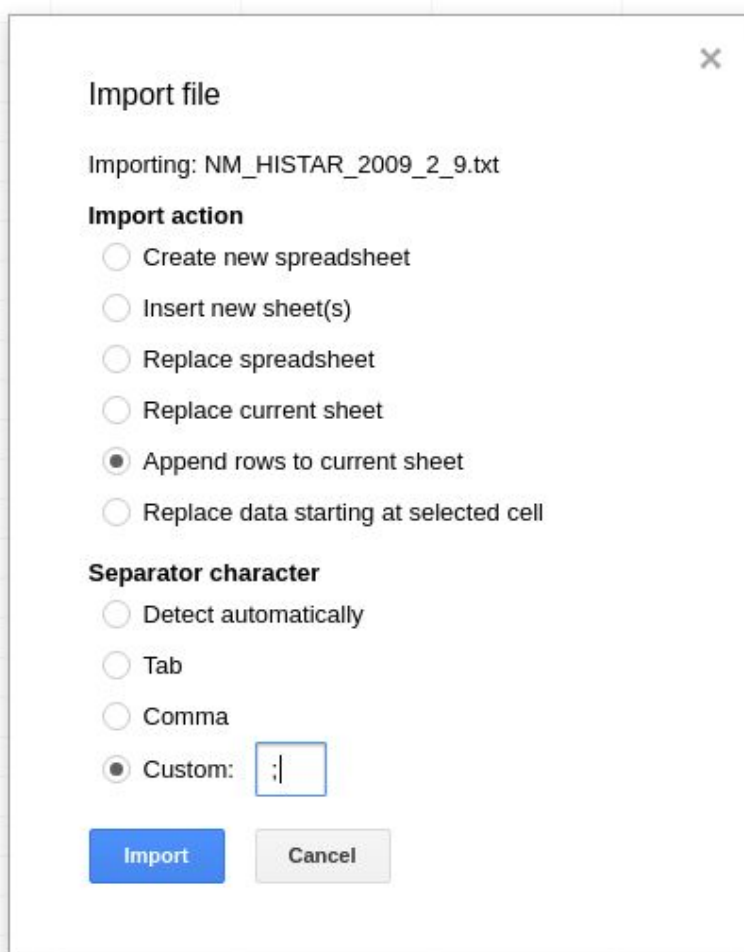


c. Select upload



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 ;



The image shows a dialog box titled "Import file" with a close button (X) in the top right corner. The text "Importing: NM_HISTAR_2009_2_9.txt" is displayed. Under the "Import action" section, there are six radio button options: "Create new spreadsheet", "Insert new sheet(s)", "Replace spreadsheet", "Replace current sheet", "Append rows to current sheet" (which is selected), and "Replace data starting at selected cell". Under the "Separator character" section, there are four radio button options: "Detect automatically", "Tab", "Comma", and "Custom:" (which is selected). Next to the "Custom:" option is a small text input field containing a semicolon and a vertical line (;|). At the bottom of the dialog are two buttons: "Import" (in blue) and "Cancel" (in grey).

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.

Connected to:db04.nmdb.eu

back&reset back log prev step zoom left zoom center zoom right zoomout next step

the MySQL query <http://linkconditions.com> & 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

Times

NM Counts/s

	OULU	FSMT	NAIN	THUL
5/9/2009 0:00:00	113.655	229.234	223.891	131.179
5/9/2009 0:30:00	113.221	230.422	224.409	131.078
5/9/2009 1:00:00	113.606	230.148	223.992	130.936
5/9/2009 1:30:00	113.292	229.827	223.753	131.528
5/9/2009 2:00:00	113.381	229.663	223.415	131.205
5/9/2009 2:30:00	113.042	230.291	224.88	131.447
5/9/2009 3:00:00	113.202	229.881	224.971	131.458

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

Untitled spreadsheet

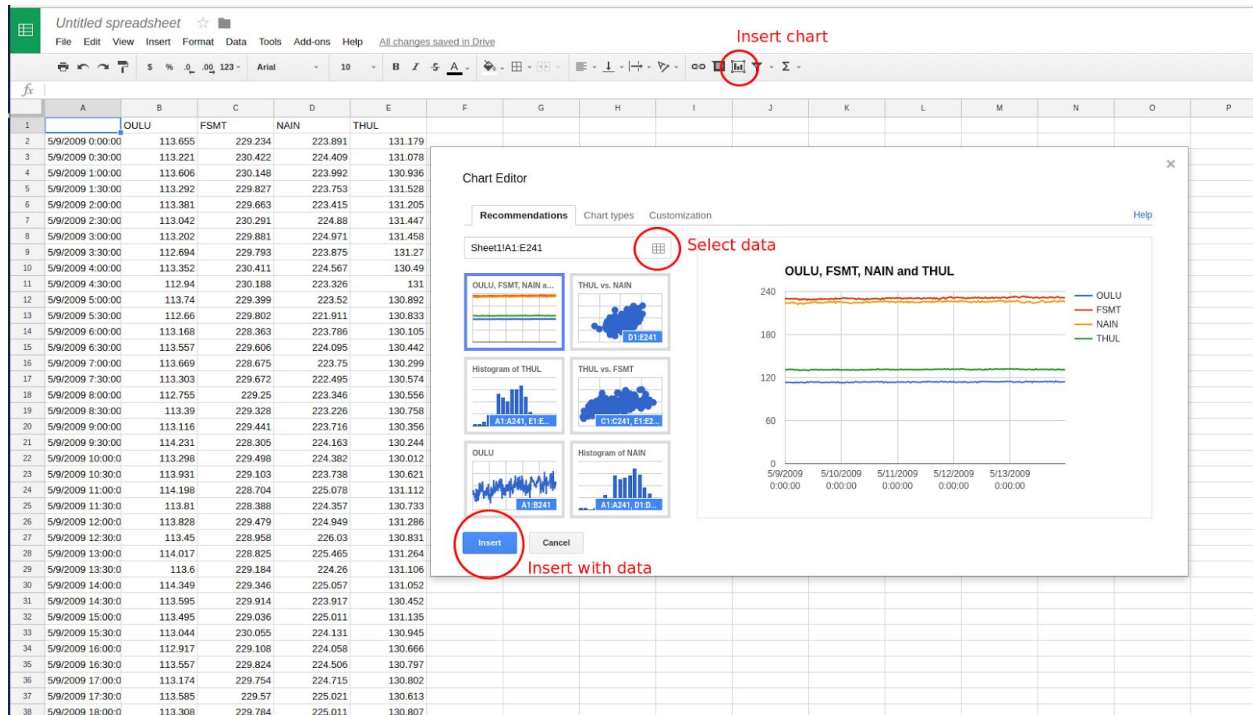
File Edit View Insert Format Data Tools Add-ons Help All changes saved in Drive

	A	B	C	D	E	F	G	H
1		OULU	FSMT	NAIN	THUL			
2	5/9/2009 0:00:00	113.655	229.234	223.891	131.179			
3	5/9/2009 0:30:00	113.221	230.422	224.409	131.078			
4	5/9/2009 1:00:00	113.606	230.148	223.992	130.936			
5	5/9/2009 1:30:00	113.292	229.827	223.753	131.528			
6	5/9/2009 2:00:00	113.381	229.663	223.415	131.205			
7	5/9/2009 2:30:00	113.042	230.291	224.88	131.447			
8	5/9/2009 3:00:00	113.202	229.881	224.971	131.458			
9	5/9/2009 3:30:00	112.694	229.793	223.875	131.27			
10	5/9/2009 4:00:00	113.352	230.411	224.567	130.49			
11	5/9/2009 4:30:00	112.94	230.188	223.326	131			
12	5/9/2009 5:00:00	113.74	229.399	223.52	130.892			
13	5/9/2009 5:30:00	112.66	229.802	221.911	130.833			
14	5/9/2009 6:00:00	113.168	228.363	223.786	130.105			

III. Make Plots and Identify Trends

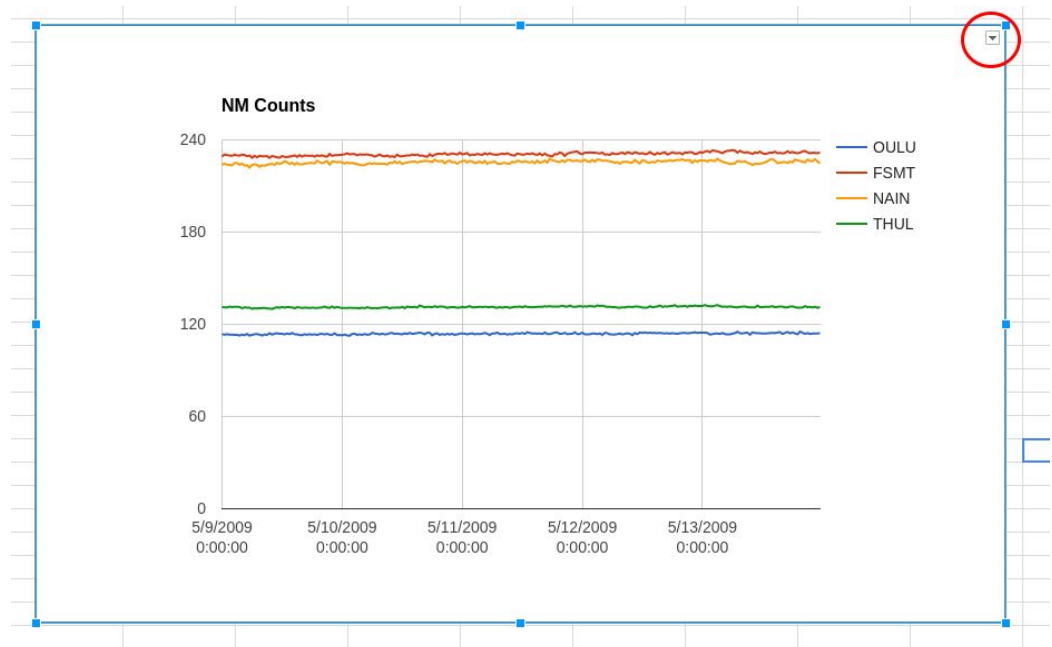
1. Now in the spreadsheet we can make plots of the data.

- 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?

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.

	A	B	C	D	E	F
1		OULU	FSMT	NAIN	THUL	
2	5/9/2009 0:00:00	113.655	229.234	223.891	131.179	
3	5/9/2009 0:30:00	113.221	230.422	224.409	131.078	
4	5/9/2009 1:00:00	113.606	230.148	223.992	130.936	
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				
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				
13	5/9/2009 5:30:00	112.66				
14	5/9/2009 6:00:00	113.168	228.363	223.786	130.105	
15	5/9/2009 6:30:00	113.557	229.606	224.095	130.442	
16	5/9/2009 7:00:00	113.669	228.675	223.75	130.299	

- b. Do you see any trends in the data?

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

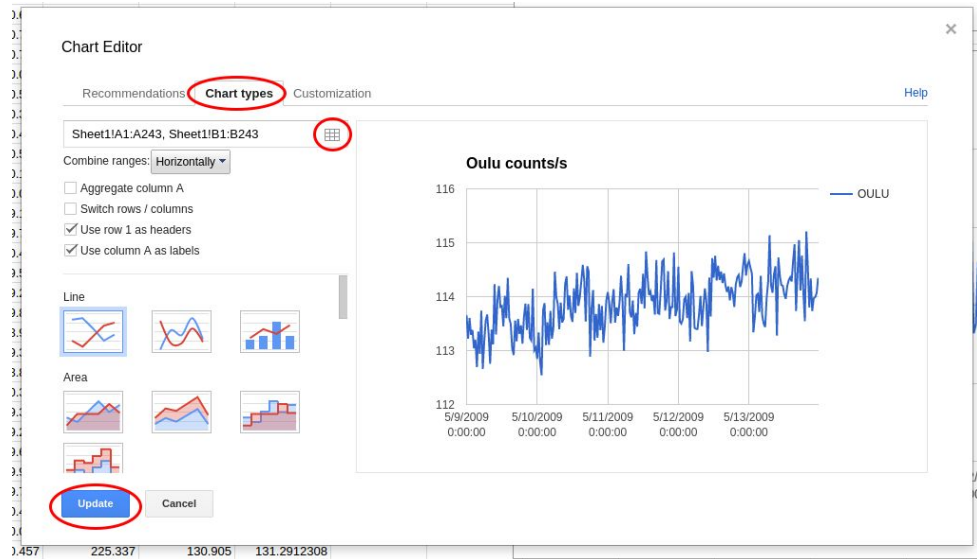
	A	B	C	D
1		OULU	Oulu Avg	FSMT
2	5/9/2009 0:00:00	113.655		229.2
3	5/9/2009 0:30:00	113.221		230.4
4	5/9/2009 1:00:00	113.606		230.1
5	5/9/2009 1:30:00	113.292		229.8
6	5/9/2009 2:00:00	113.381		229.6
7	5/9/2009 2:30:00	113.042	113.2271538 ×	230.2
8	5/9/2009 3:00:00	113.202	=average(B2:B14)	229.8
9	5/9/2009 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

- 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)

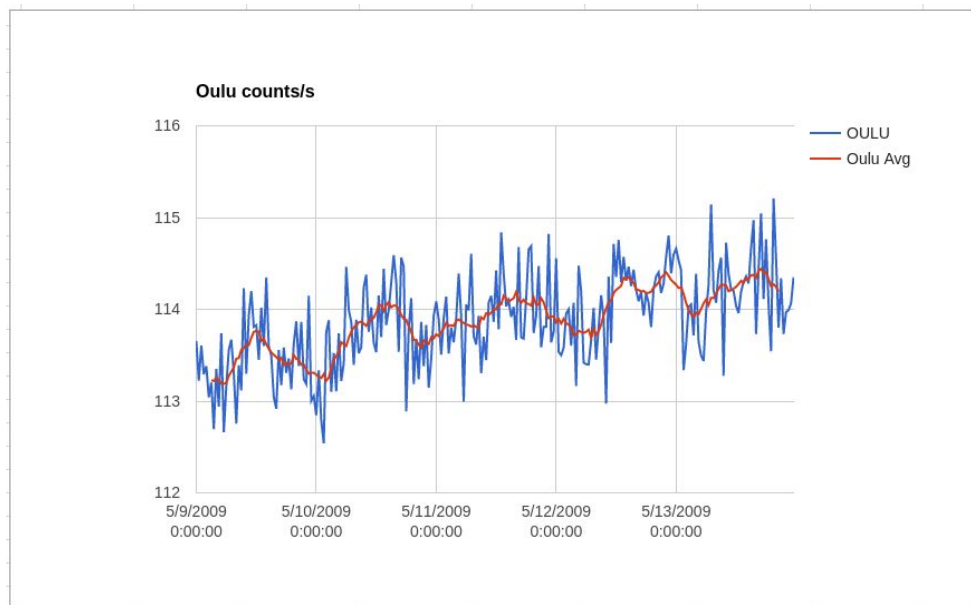
<div> <div> <div></div> <div></div> <div></div> <div></div> </div> <div> <div>\$</div> <div>%</div> <div>.0</div> <div>.00</div> <div>123 ▾</div> </div> <div>Arial</div> </div>				
fx =average(B2:B14)				
	A	B	C	
1		OULU	Oulu Avg	FSMT
2	5/9/2009 0:00:00	113.655		
3	5/9/2009 0:30:00	113.221		
4	5/9/2009 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?

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?
