Cloudy with a Chance of Muons

Or

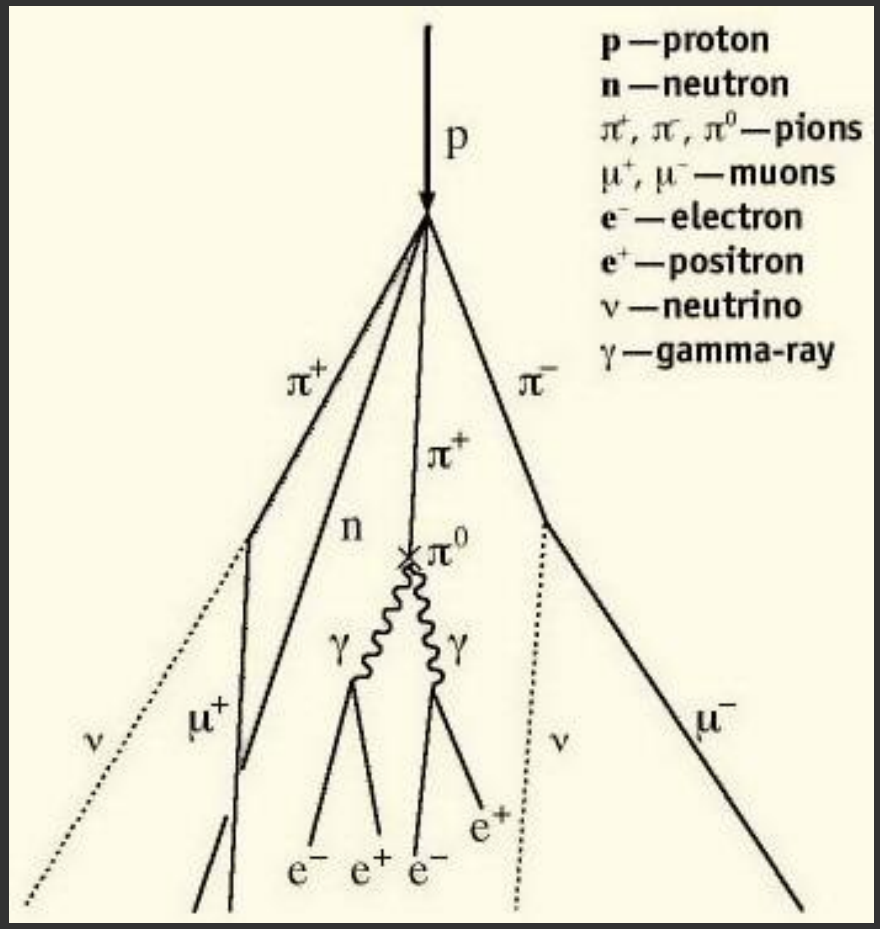
An Investigation into the Relationship between Barometric Pressure and Muon Detection

What were we investigating?

- We were investigating the effect of barometric pressure on muon detection

Some Basic Theory

- The muons we were looking at are produced in the atmosphere when cosmic rays impacted particles within the atmosphere causing an interaction of the high energy protons forming many by-products including muons.



How we detected the muons.

- We detected the muons within a scintillator. The scintillator contains a scintillating material and light detectors.
- Muon decays were differentiated due to 2 flashes: 1 for muon, 1 for electron.

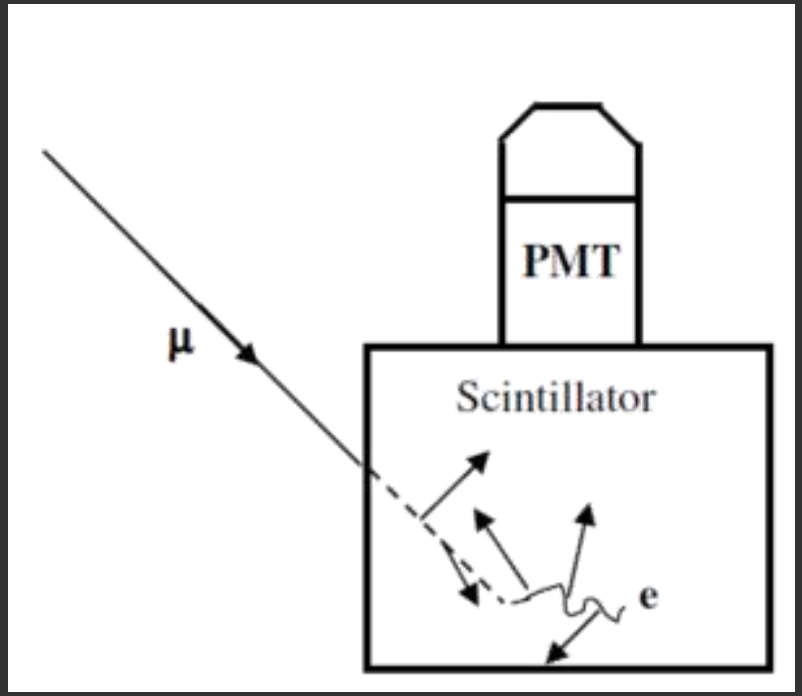


Figure 2. How a scintillator works

The More Interesting Theory

- We thought that an increase in barometric pressure would cause less muons to be detected.
- A higher pressure would mean more particles per unit volume of the atmosphere
- This should mean that more muons collide or interact with other particles, causing them to decay before we can detect them

Practical Data

- We collected 16 million points of data
- But we had to remove the majority of that data
- We plotted a graph of the remaining data and had to remove some of that as well

Errors with data gathering (Muons)

- We managed to find a large section of uninterrupted data
- But we had to remove some data as it was wildly inconsistent with both the rest of the data and accepted values.

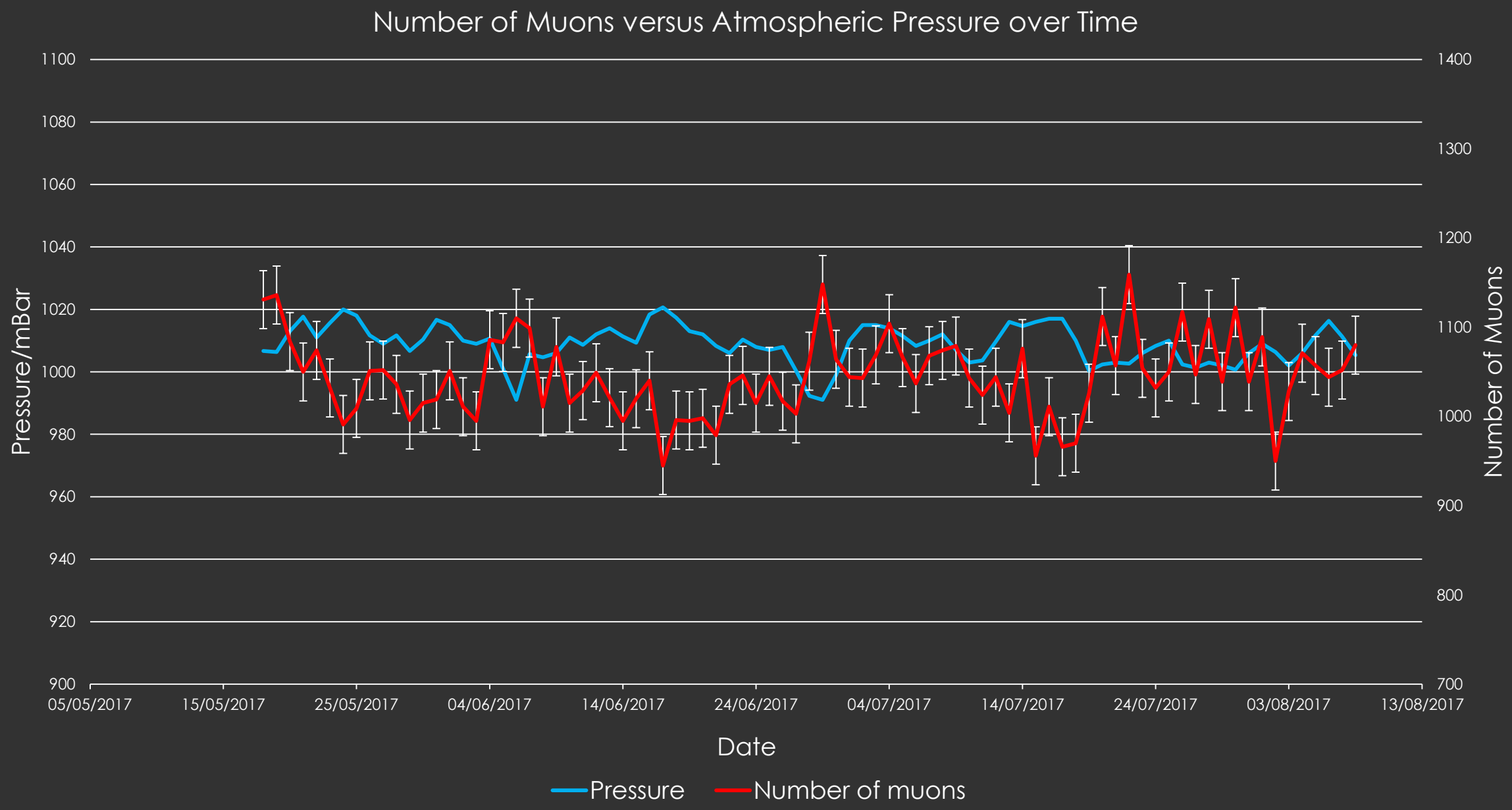


Figure 3. Graph of muons detected against pressure in Summer

That wasn't all the data we collected

- From the 8th of August to the 17th there was a pause in the data collection for barometric pressure

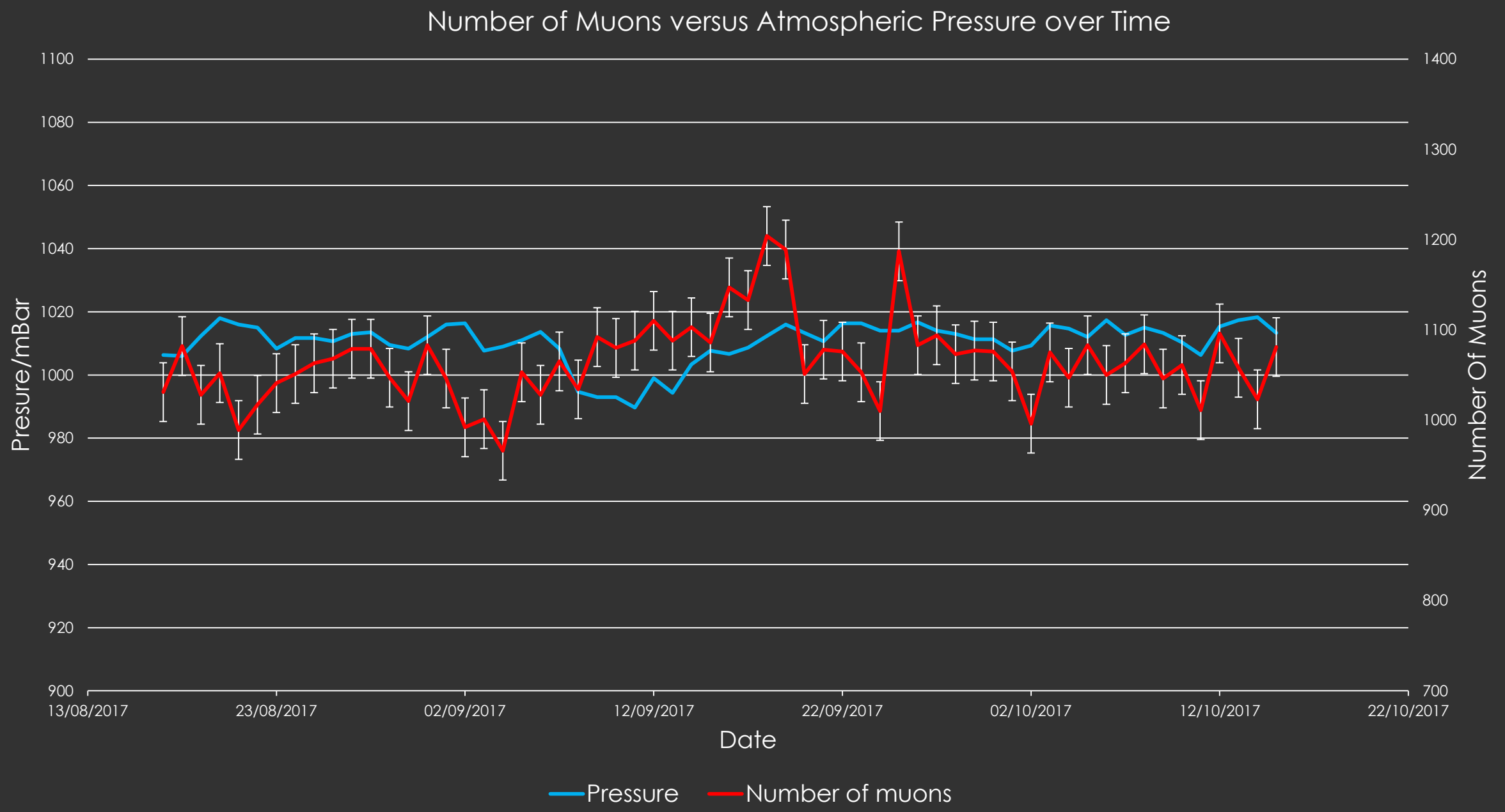


Figure 4. Graph of muons detected against pressure in Autumn

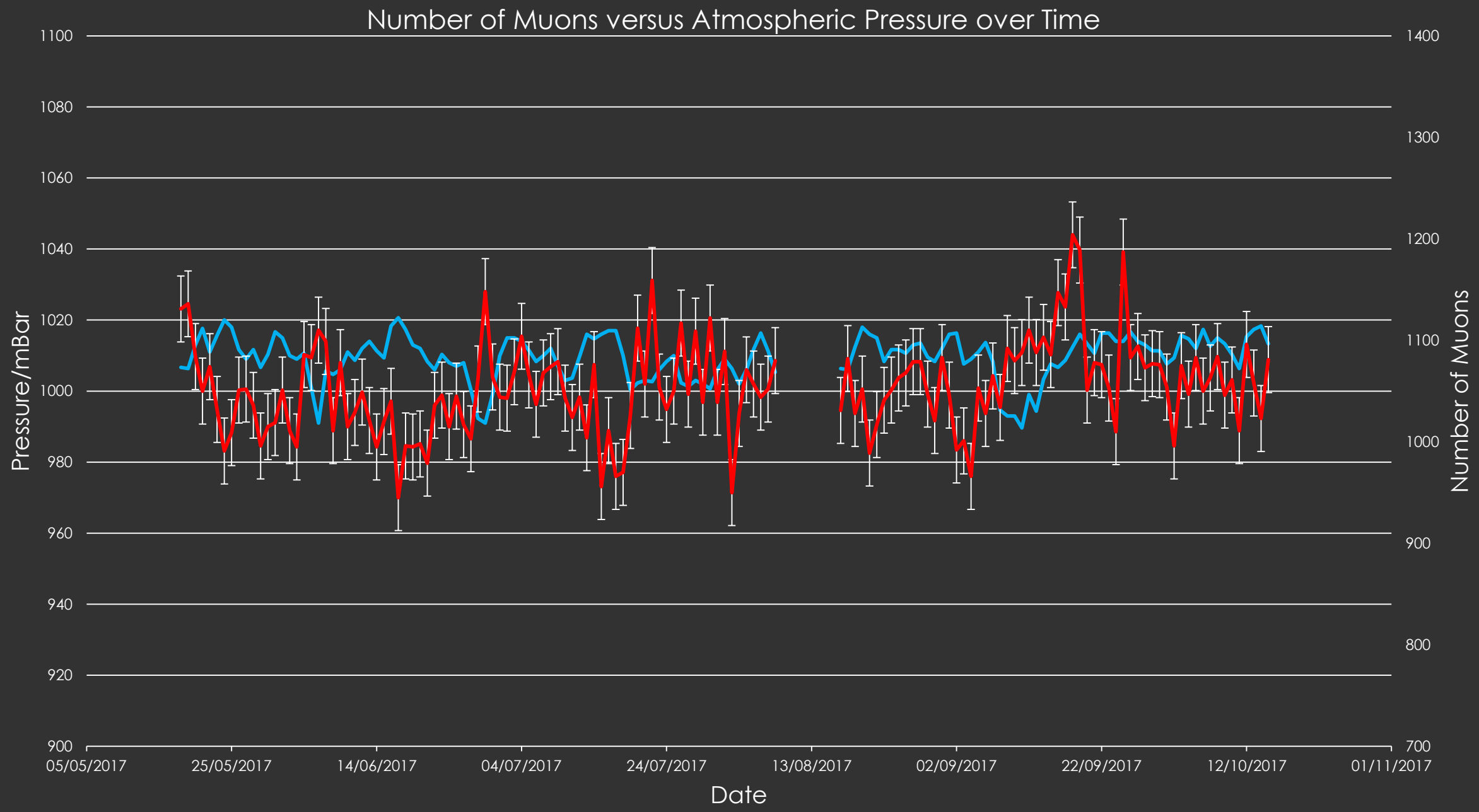


Figure 5. Complete graph of muons detected against pressure

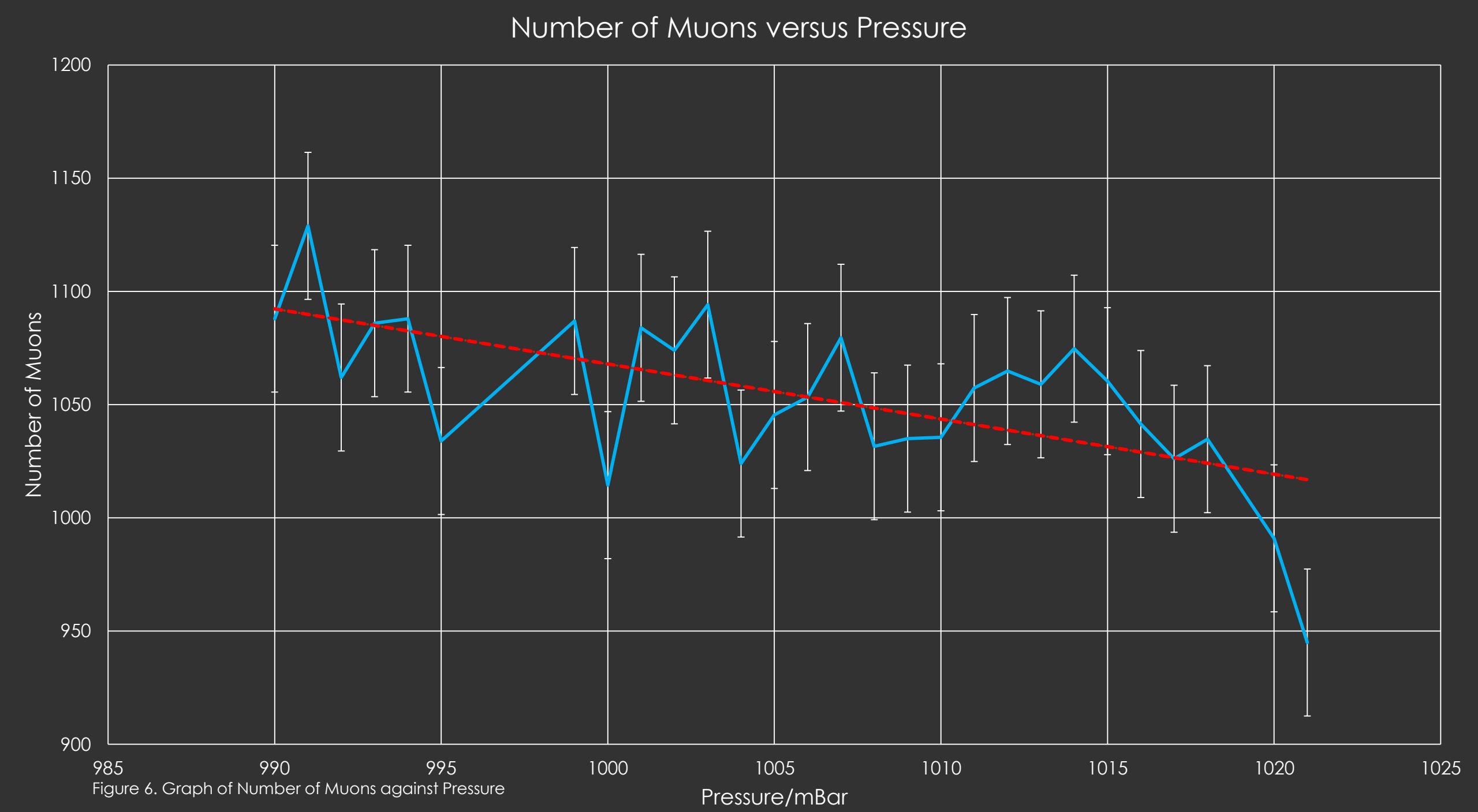


Figure 6. Graph of Number of Muons against Pressure

Data analysis

- We found an overall correlation coefficient of -0.267.
- This suggests a small correlation

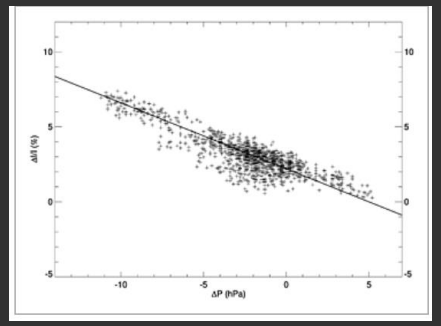
(https://statistics.laerd.com/statistical-guides/pearson-correlation-coefficient-statistical-guide.php)

Errors with gathering data about pressure

- After the gap in the data our correlation dropped, so the gap may have affected the data collected
- (Clearly King's College isn't as well organised as Queen Mary)

Conclusion for hypothesis

- Based on our data, we think there may be some relationship between barometric pressure and cosmic ray muon detection
- Although our data was inconsistent and didn't show this in full, it agreed with another study we found (although much more weakly) (De Mendonça, Paulin, Echer, Makhmutov and Fernandez, 2013)



correlation coefficient ~0.9

Figures 7 and 8. (De Mendonça, Paulin, Echer, Makhmutov and Fernandez, 2013)

Conclusion for data analysis

- As well as learning about the impact of the weather on muon detection, we learned some important lessons about data analysis, correlation and causation.

We now know how to avoid graphs and conclusions like this

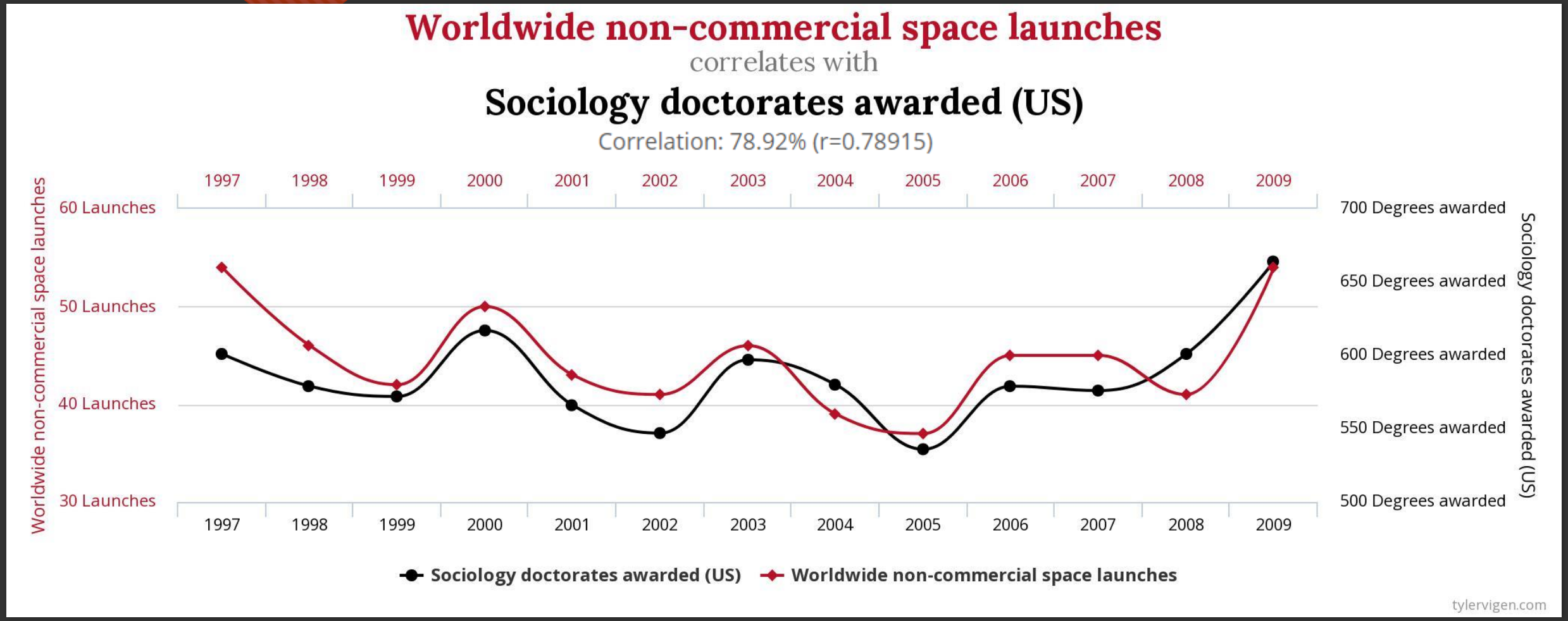


Figure 9. (Tyler Vigen)

References

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- Figure 2. How a scintillator works. Retrieved from: http://physicsopenlab.org/2016/01/04/scintillation-muons-detector/
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- Figure 9. Tyler Vigen. Graph to show relationship between sociology doctorates and non-commercial space launches. Retrieved from: http://www.tylervigen.com/spurious-correlations

Thank you for listening!