Data analysis aboard of the Amerigo Vespucci

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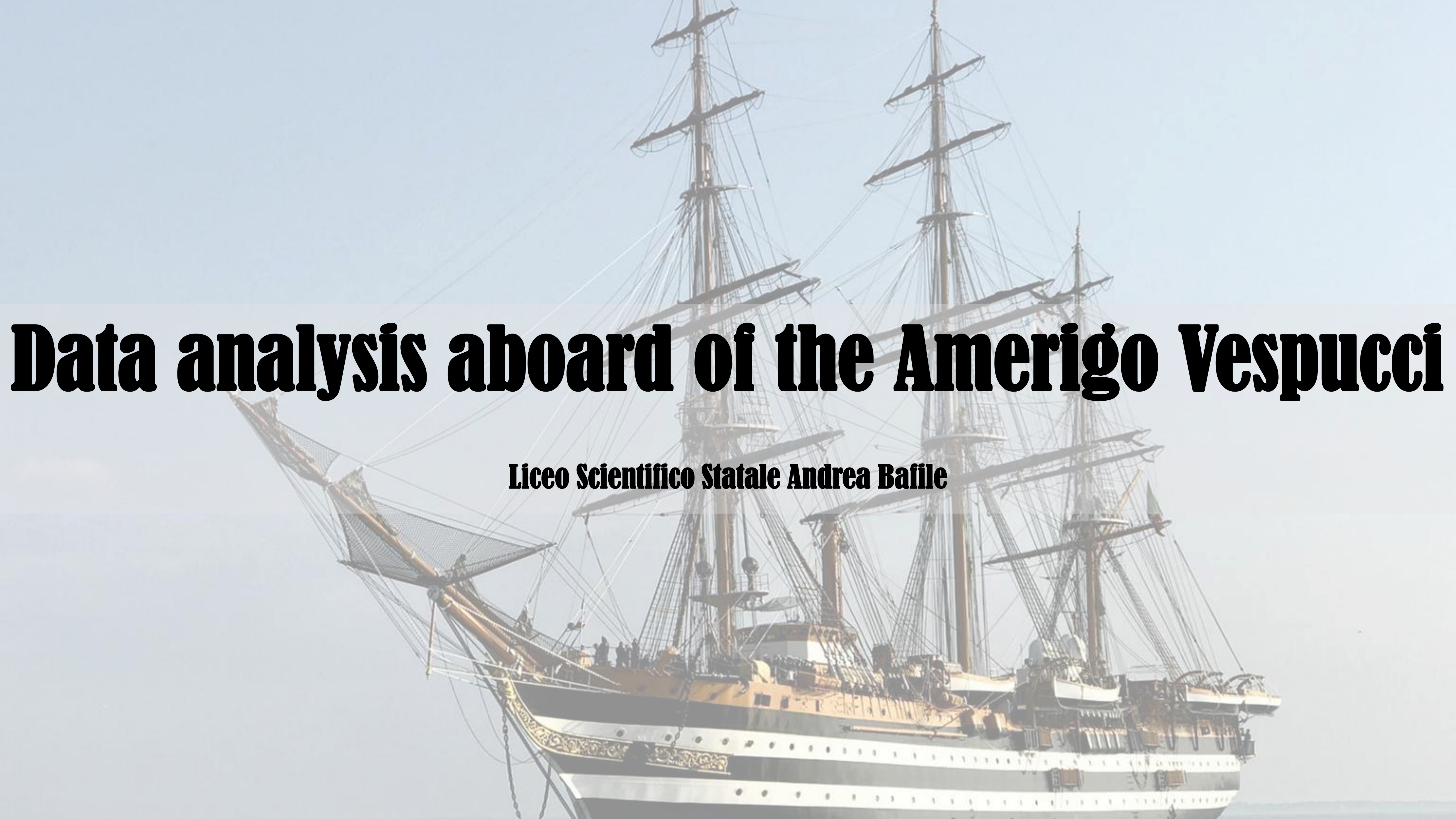


Introduction

Using the data acquired from POLA-02 detector we studied the variations in muon flux as a function of latitude.

POLA-02 consists of two planes of 1 cm thick scintillators, each divided into four equal tiles of 20×30 cm^2 .

Readout is performed by means of silicon photomultipliers (SiPMs), two per tile, positioned at opposite corners.

Time stamp and detector position are obtained through GPS signals. Pressure is measured by means of suitable sensor.

Starting from the pre-processed data

In October 2022, the Italian ship Amerigo Vespucci sailed through the sea. During the voyage, the cosmic rays detector POLA-02 was in function.

1	Run	Rate(Hz)	RateEffCo	pressure(m	Tin(Â°C)	Tout(Â°C)	latitude(Â°)
2	497621850	30,6	30,81	1023,74	32,5	25,75	45,65
3	497621850	31,78	32	1023,67	32,5	25,75	45,65
4	497621850	30,53	30,75	1023,13	32,56	25,75	45,65
5	497621850	30,32	30,53	1023,01	32,56	25,75	45,65

We were given two data set: one when the Vespucci was stationary and one when it was moving.

We started our analysis from the first one

Barometric correction

We began applying the barometric correction on the given data, using the Excel function:

=RateEffcorr*EXP(a*(Pressure-Pr)

	A	B	C	D	E	F	G	H
1	Run	Rate(Hz)	RateEffCo	pressure(n	Tin(Â°C)	Tout(Â°C)	latitude(Â°)	RatePcorr
2	497621850	30,6	30,81	1023,74	32,5	25,75	45,65	31,51
3	497621850	31,78	32	1023,67	32,5	25,75	45,65	32,72
4	497621850	30,53	30,75	1023,13	32,56	25,75	45,65	31,40
5	497621850	30,32	30,53	1023,01	32,56	25,75	45,65	31,17
6	497621850	30,35	30,56	1021,16	32,62	25,81	45,65	31,07
7	497621850	30,6	30,81	1021,86	32,62	25,81	45,65	31,37
8	497621850	30,88	31,1	1022,25	32,69	25,88	45,65	31,70

- **a=2.3E-3**
- **Pr=1014mbar**

Considering the latitude

Since the Vespucci was actually a “moving detector”, we had to consider the effect of the variation of the latitude on the data

	A	B	C	D	E	F
1	Run min	Run max	Rate (Hz)	Err rate	Latitudine	Rate (Hz)
2	[illegible]	[illegible]	30,74	0,06	39,81	30,74
3	498396949	498431282	31,04	0,04	41,31	31,05
4	499232479	499279006	31,22	0,04	42,09	31,22
5	499342599	499380507	31,42	0,04	43,55	31,41
6	497949557	498003629	31,63	0,03	43,62	31,62
7	497621850	497651749	31,42	0,05	45,65	31,40

We previously selected the most relevant run ranges in order to calculate the average rate on the fixed latitude

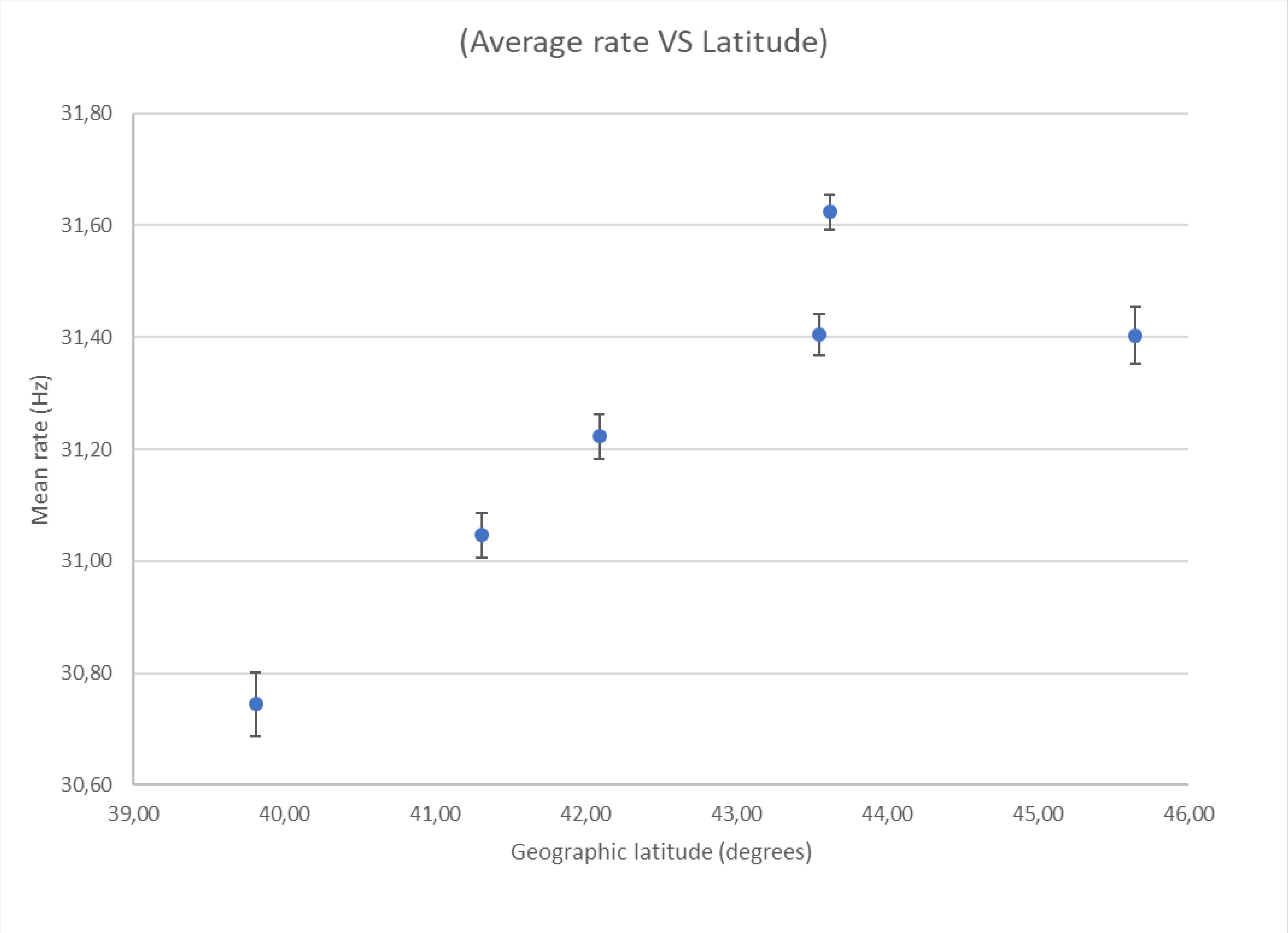
The uncertainty on the mean rate was calculated using the SDOM (Standard Deviation of the Mean).

Its formula is:

$$\text{SDOM}=\frac{\sigma}{\sqrt{N}}$$

where N is the domension of the sample and σ is their standard deviation

Considering the latitude



So, we obtained this graph.

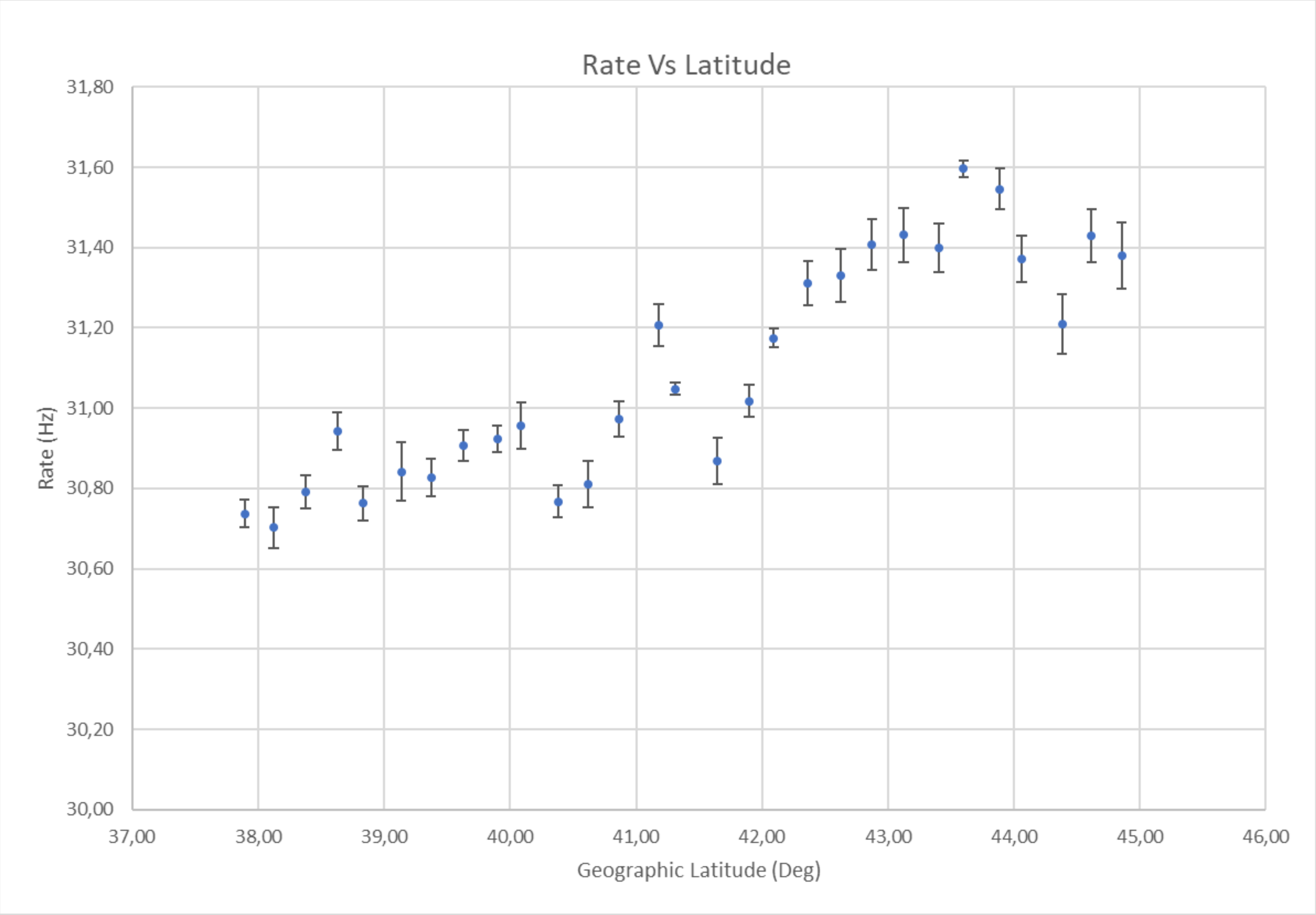
In the considered range, we notice an increase in the rate with latitude

Analysing the second data set

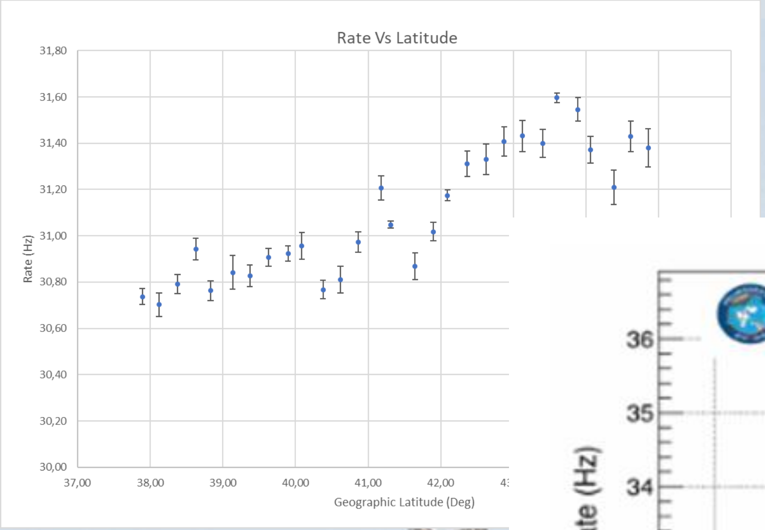
After having applied the barometric correction, the run selection was based on both the run range and
the latitude range where the Vespucci was at the time of measurement.
We obtained the graph on the right.

This time we had to consider latitude ranges, since the ship was actually moving and we did not have fixed positions.

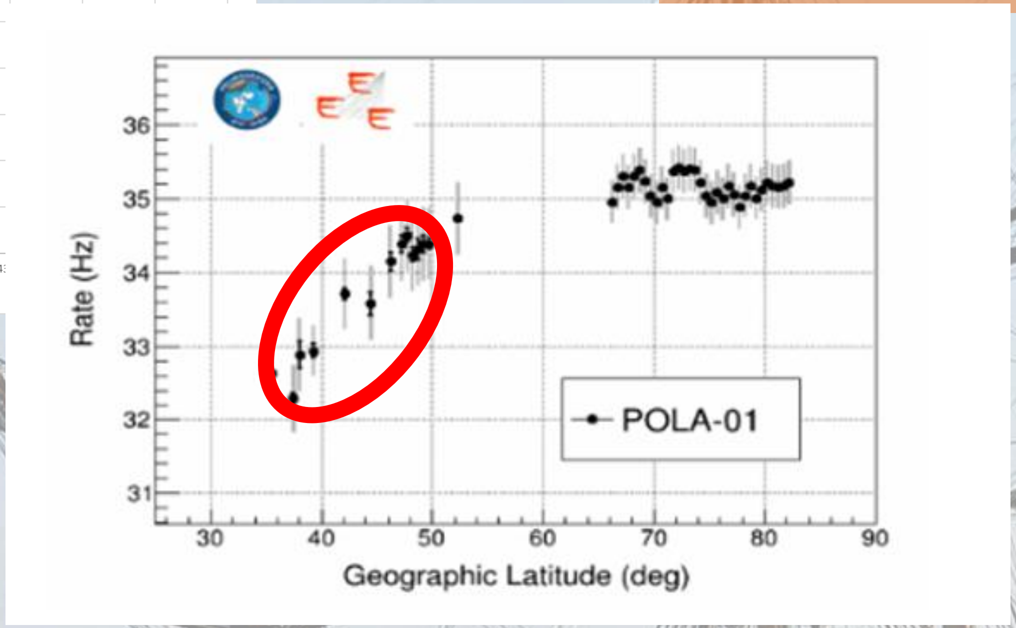
So, in order to draw the graph, we calculated the average latitude as the arithmetic mean of the latitudes measured in the relevant ranges.

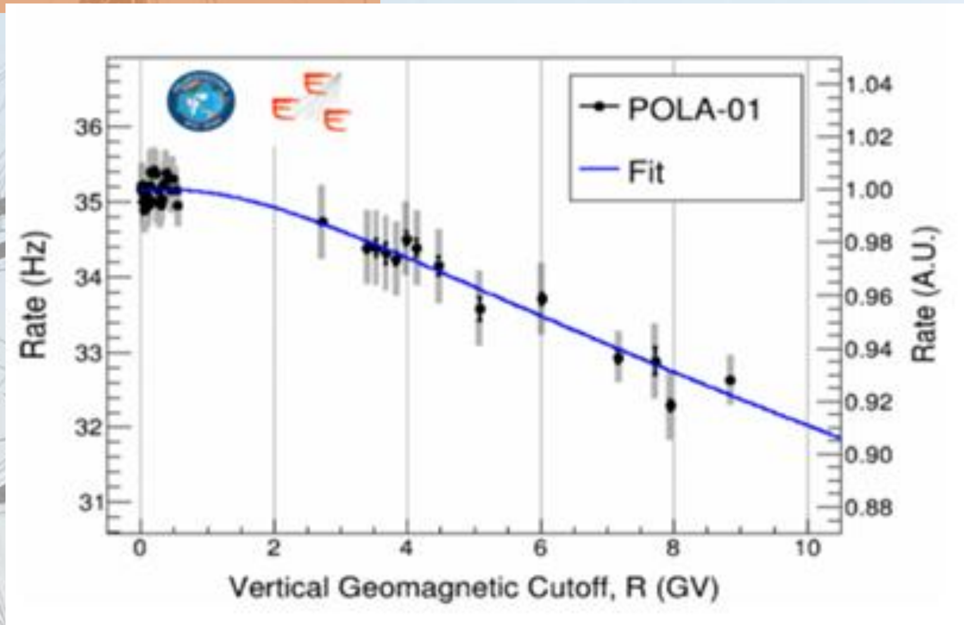


Final considerations



M. Abbrescia et al. (EEE Collaboration), “Measurement of the cosmic charged particle rate at sea level in the latitude range 35° ÷ 82° N with the PolarquEEEst experiment”, Eur. Phys. J.C 83, 293 (2023). https://doi.org/10.1140/epjc/s10052-023-11353-w.





The increase of the mean rate in function of the latitude shown in our graph, follows the trend forecasted by the scientific literature. The red box in the graph, from Abbrescia’s paper, highlights this increase in the latitude range we analyzed.

In order to justify this trend, we can consider the role of the geomagnetic field: the closer we are to the equator, the more effective the magnetic field shielding is, as the vertical geomagnetic cutoff increases.