Extreme Energy Events
Science inside Schools

International Cosmic Day

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Circumnavigation on Svalbard' islands

Here we analyzed the data acquired by the POLA-01 detector on board the Nanuq on July 30, 2018 when the boat ran aground and tilted, and studied the trend of the muons rate as a function of the zenith angle of arrival.

Summary

- Analyzing the data collected on Nanuq's trip to Svalbard Islands. First, it is necessary to analyze the muons flux incident on the entire surface of the detector planes. Second, the analysis is based on a quarter of the surface of the detector planes, which decreases the geometric acceptance.

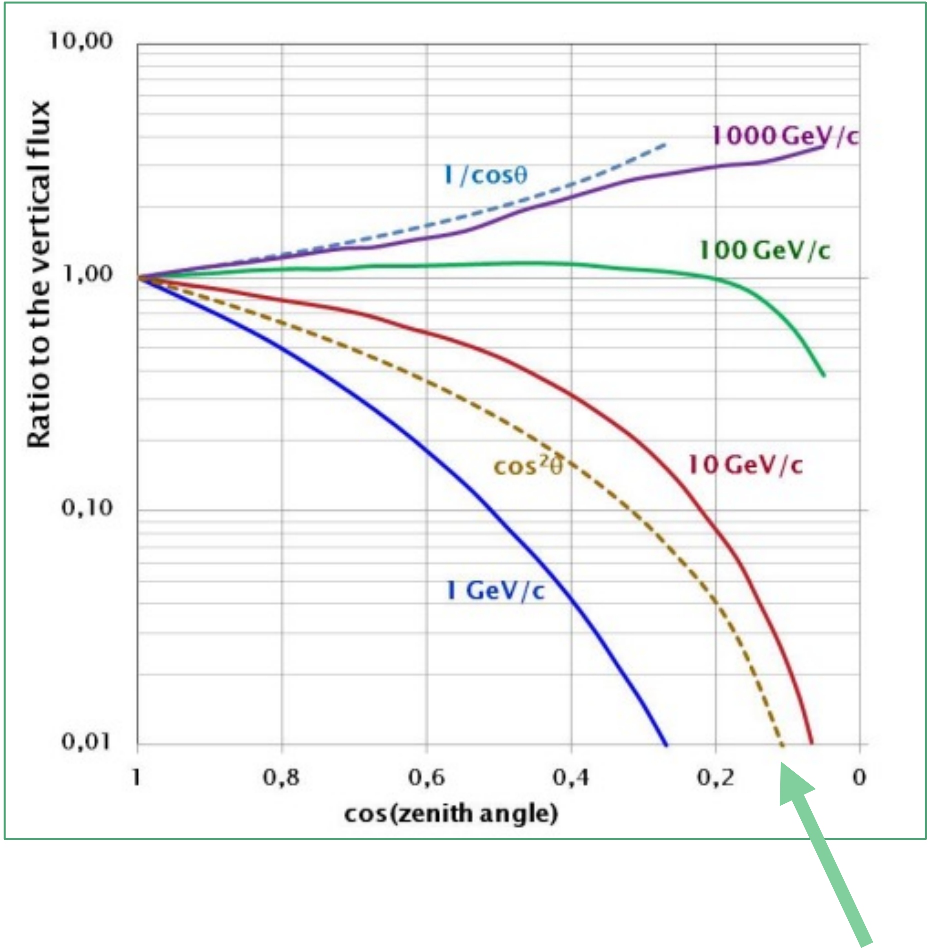
- Proving the relationship between the muons flux and the zenith angle.

- Checking that the trend is $\cos^2\theta$ in agreement with literature.

The overall angular distribution of muons measured at sea level is $\propto \cos^2\theta$ which is characteristic of muons with $E_\mu \sim 3$ GeV. The estimate of the angular distribution is based on a Monte Carlo simulations and accounts for the curvature of the Earth's atmosphere

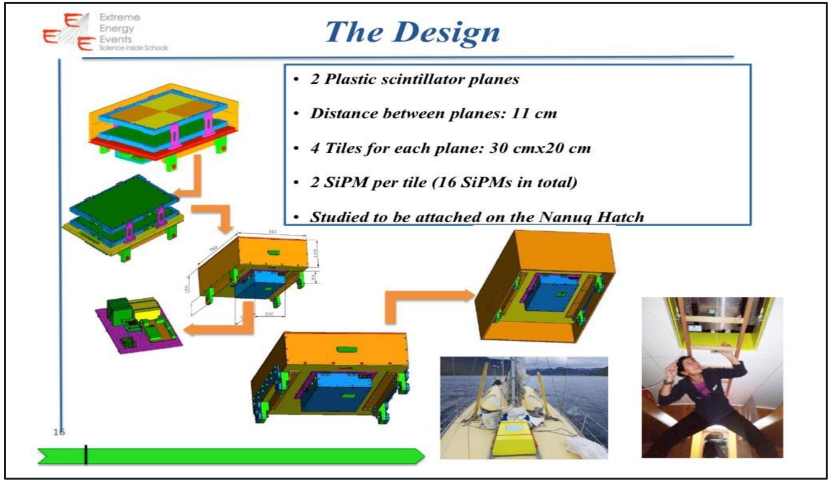
The mean energy of muons at sea level is about 3-4 GeV.

Moreover, the muon intensity from the horizontal directions at low energies is naturally reduced because of muon decays and absorption effects in the thicker atmosphere at large zenith angles.



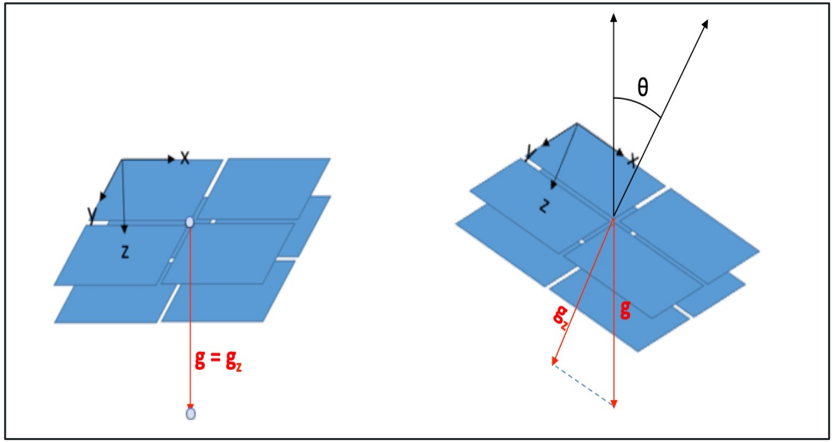
Analysis

We analyzed the data acquired by the POLA-01 detector on board the Nanuq on July 30, 2018. It was possible to carry the detector inside the boat due to his small dimensions of 30cmx20cmx11cm. Direction information is obtained by an accelerometer which gives acceleration expressed in g in the directions X, Y e Z.

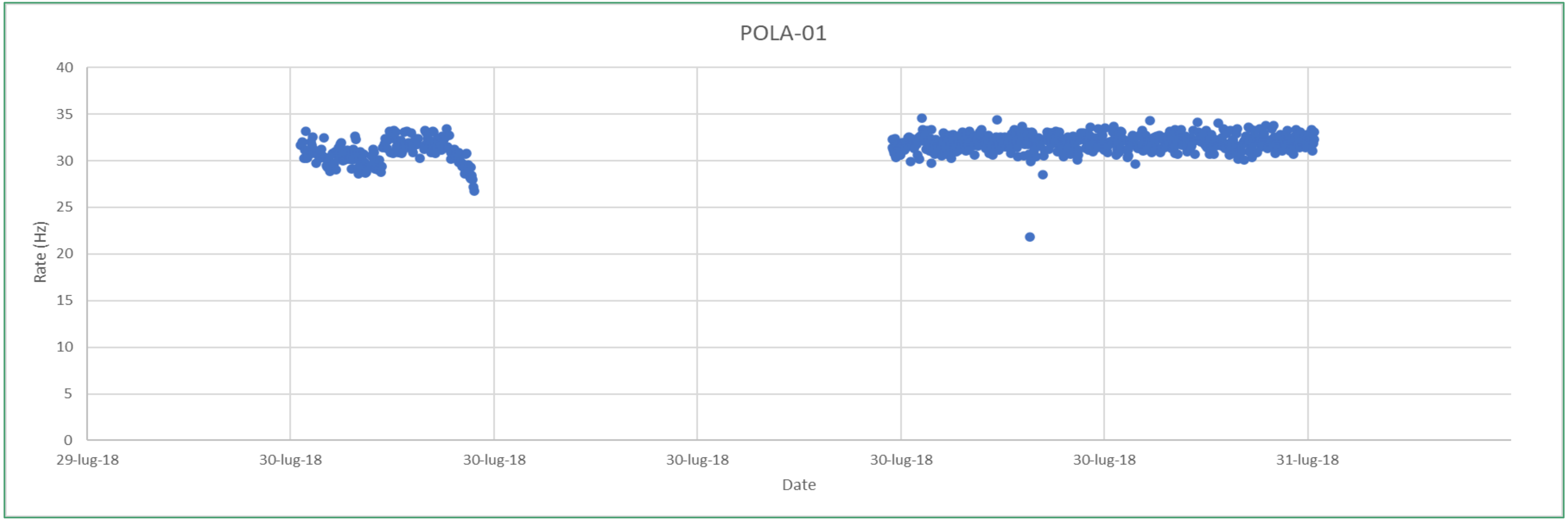


The first phase of our work, the production of graphs, was simultaneously carried out by 2 independent groups of students.

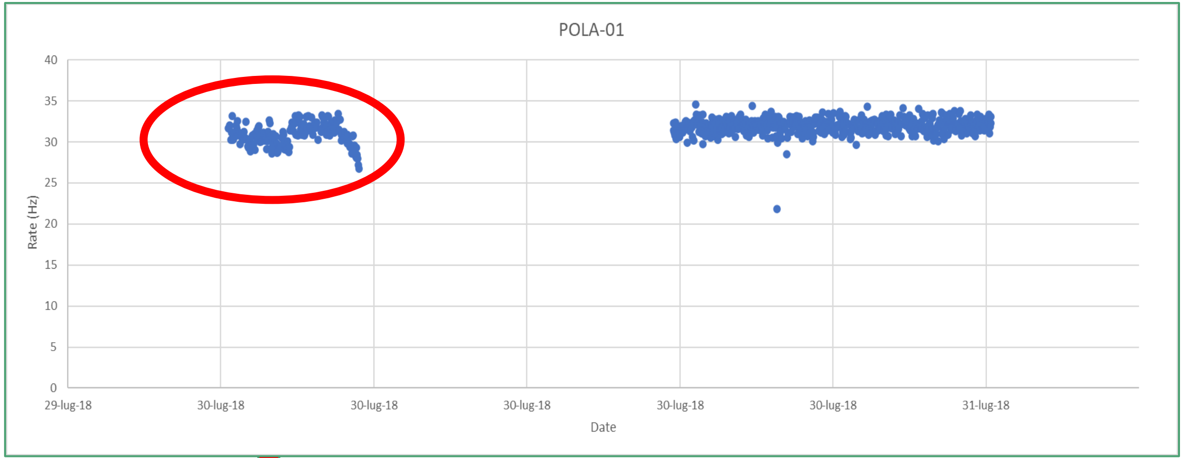
The graphs obtained were equivalent, therefore we can be more certain of the accuracy of the project, as the possibility of human error is statistically reduced.

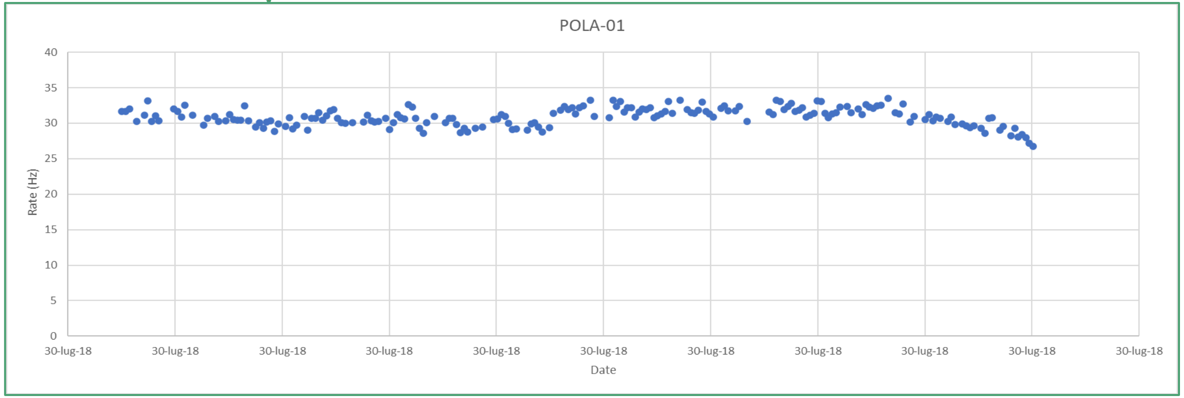


Data analysis

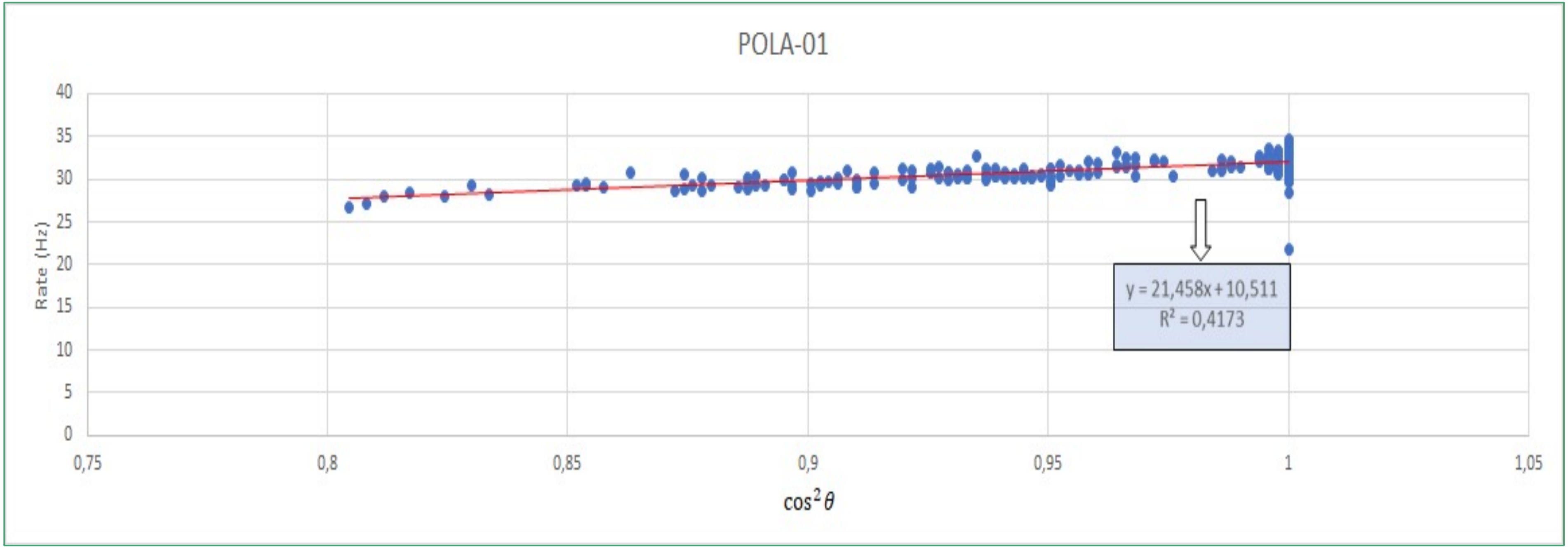


Here we created the scatter plot graph by placing on the abscissae the Date and on the ordinates the Rate (Hz), which is the number of muon traces measured per second. The percentage of cosmics absorbed depends on the energy of the cosmics themselves. There is a relationship between the angular distribution of how cosmic rays arrive to the ground detector and their energy.





Let's consider the first part of the graph, before the detector was turned off for 9 hours. We noticed that the muon flux curves due to the fact that the boat was tilting, and the muon flux changes as the zenith angle increases. As the angle changes, the cosmic distribution changes: this is seen by rotating boat and so the detector on the boat.

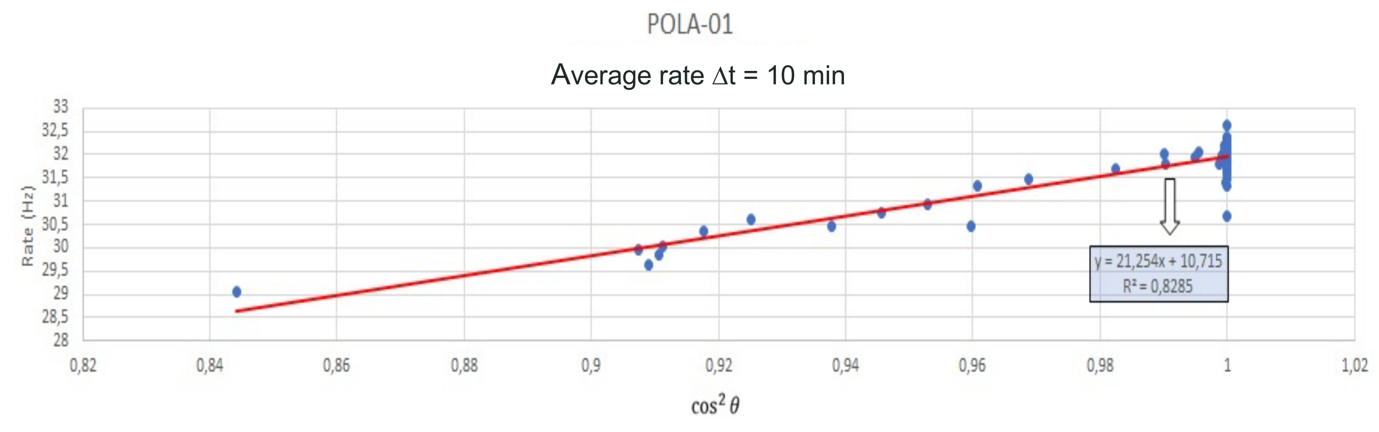


The muons flux at sea level varies as a function of the zenith angle (theta) with a function like $\cos^2\theta$. This is in agreement with literature, the overall angular distribution of muons measured at sea level is $\propto \cos^2\theta$ for muons with an energy $E_\mu \sim 3$ GeV.

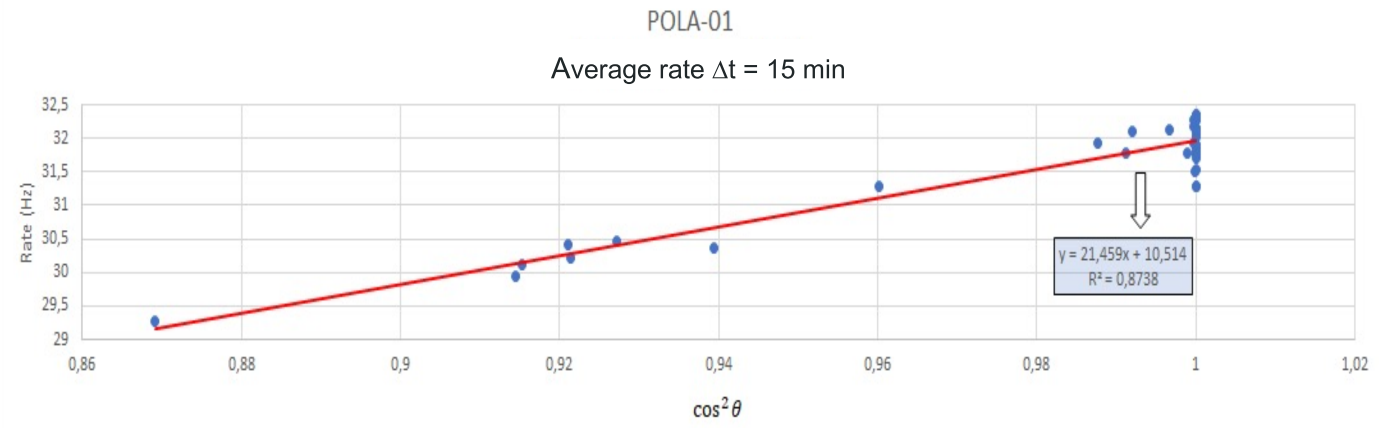
Further checks

Analysis with average rates of the whole scintillator

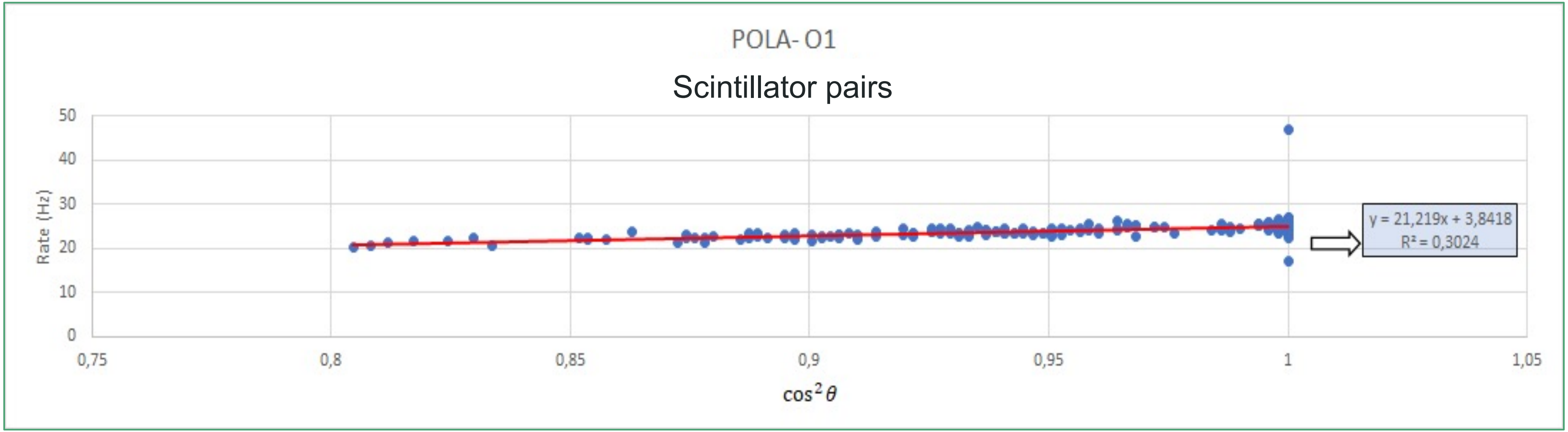
In addition to the proposed analysis, we decided to group muons rate values at **Δt = 10 min** and **Δt= 15 min**, **expecting graphs where the flux pattern was extremely clear.**



We chose two different time intervals to examine whether there were any significant changes between the two graphs, again with the goal of having the clearest analysis possible



Analysis considering scintillator pairs

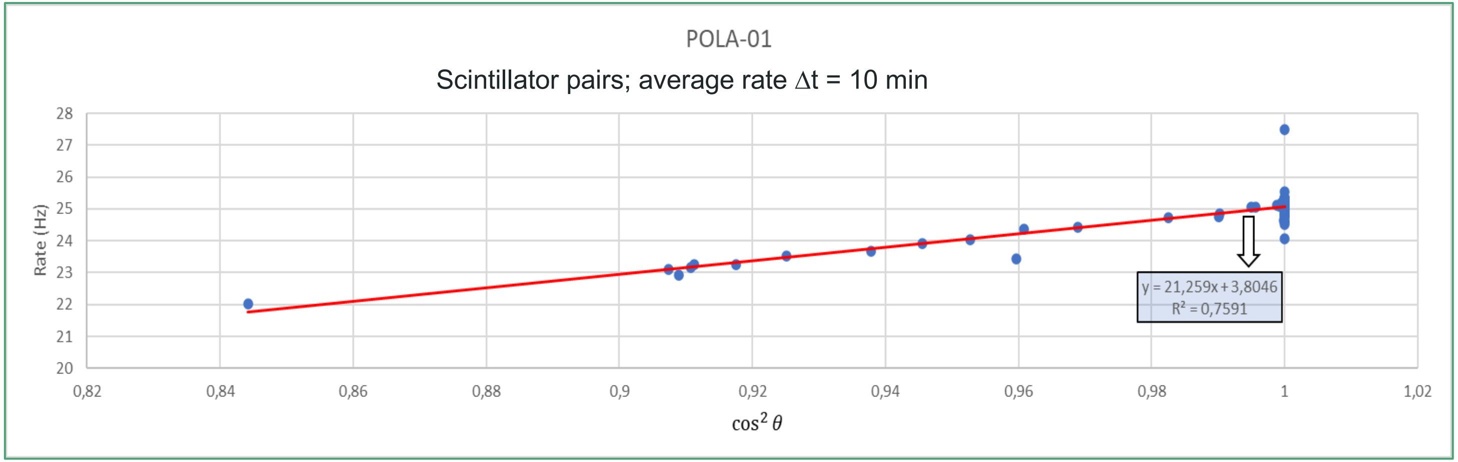


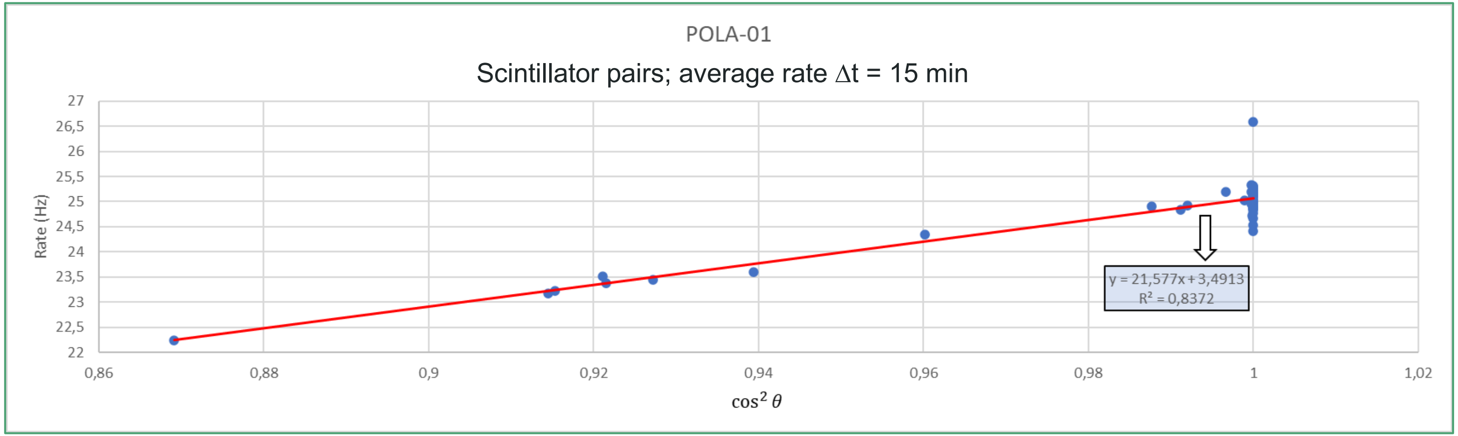
Furthermore, by **reducing the surface** of the scintillators plates, the geometric acceptance decreases. We will therefore detect only almost perpendicular rays.

This is the reason why we decided to use only 1/4 of the surface area of the scintillator pairs, expecting to get a **clearer $\cos^2\theta$ trend plot.**

Scintillator pairs with average rates

At last, we have analyzed the flux trend in the two different time intervals considering a **lower geometric acceptance**, as we did in the first analysis. Again, as we expected, the best-fit line is a straight line that has a trend like $\cos^2\theta$.
In addition, we can observe how the data are less scattered, even if the graphs are formed by an average of the data and therefore less punctual in the values of individual points.
We notice that R^2 values are comparable, and there are not many differences between
Δt = 10 min and
Δt = 15 min





Conclusions

- We were able to prove that the muons flux changes depending on the angle and inclination of the detector with a function of $\cos^2\theta$.
- In the second part of the analysis, we also realized that the latter component that influences the data acquisition is the **geometric acceptance**, because by reducing the absorption surface, we get a cleaner analysis, observing only the rays almost perpendicular to the surface of the detector itself.
- All data collected are consistent with what is reported in the literature as shown in slide four.

Thanks for the attention