Correlation Between Muon Flux and Weather Conditions

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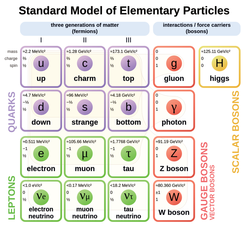
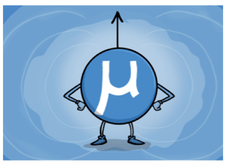
What is Muon?



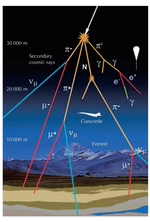


Muon is one of the sub-atomic particles in the Standard Model of particle physics:

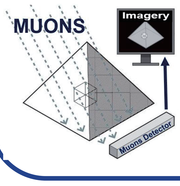
[1],

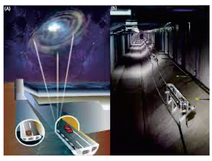
lifetime of 2.2 micro-second,
spin of 1/2 [2],
Interacts with electromagnetic and weak force.

Atmospheric Cosmic Muon

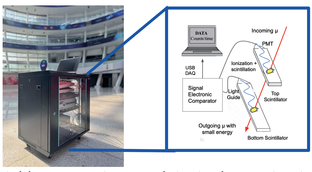


High-energy cosmic rays collide with molecules in Earth's atmosphere.
The collision produces a particle shower, including muons.
The muons can reach the Earth surface before decaying, thanks to the time dilation effect.
Muons are used in various applications, such as studying the interiors of dense objects and monitoring underground environments.



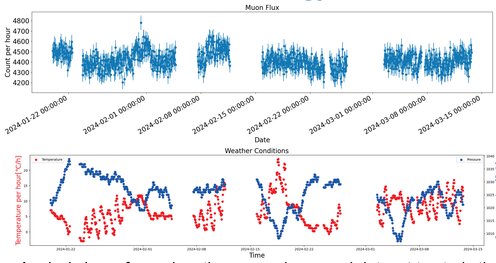


The experiment setup



A portable compact muon detector is constructed at TDLI using plastic scintillators and photomultiplier tubes.
The muon detector is used to monitor the muon flux over a period of approximately 2 months (February and March 2024).
Muons travel through both detectors produce a trigger signal; their signal pulses are analyzed in the computer system, and the hourly muon counts are recorded.
The weather datasets are obtained from the meteorological department.

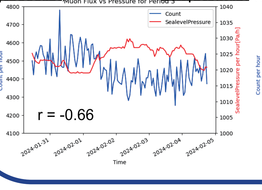
Methodology

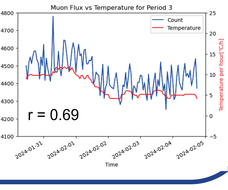


Analysis is performed on the unevenly spaced dataset to study the patterns and correlations correlation) between muon flux variations and atmospheric conditions.
The monitored muon flux dataset is segmented into nine periods, approximately one week long, for the correlation study.

Conclusion

The analysis reveals a negative correlation of -0.15 between muon flux and sea-level pressure.
Similarly, the study also shows a positive correlation of 0.20 between muon flux and temperature.
Interestingly, specific time intervals (Jan 30 - Feb 4, 2024) are highlighted with notably high correlation coefficients: **-0.66** for sea-level pressure, and **0.69** for temperature with muon flux.





Discussion and Outlook

The preliminary results suggest that higher sea-level pressure implies higher absorption of the muon component in the atmosphere, thus fewer muons are detected on the Earth surface.
The muon flux increases as the temperature increases, because higher temperatures cause a decrease in air density, thus reducing the chance for mesons to interact and resulting in a larger fraction decaying to produce muons.
The short-term study highlighted the potential application of muon flux as a method for atmospheric research.
The results can be improved by using more muon flux data and considering a more robust analysis methodology to account for effects such as altitude, geomagnetic field strength, and local geographical factors.

References

[1] Kanetada Nagamine, *Introductory Muon Science*, https://doi.org/10.1017/CBO9780511470776 (2009)
[2] B. Lee Roberts, *Muon Physics: A Pillar of the Standard Model*, https://doi.org/10.48550/arXiv.0704.2394 (2007)