

Muon rate measurements at Ny-Ålesund: correlation with atmospheric and solar parameters and seasonal studies



Ombretta Pinazza and Francesco Riggi, for the EEE Collaboration

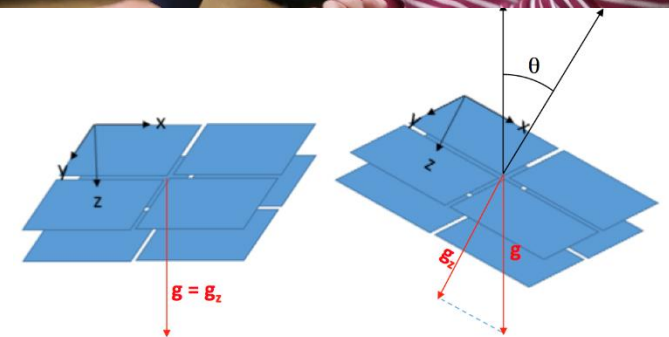
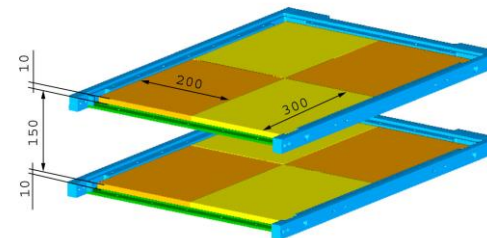
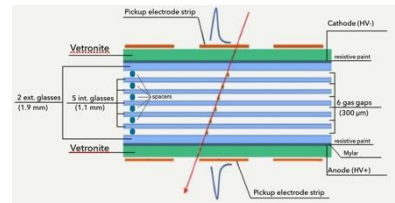


Extreme Energy Events Project

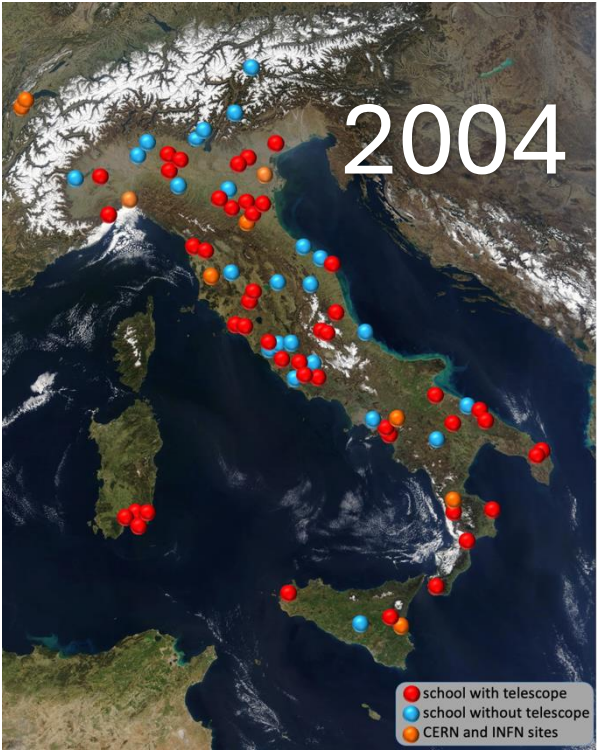
- EEE Collaboration has 60 members scientists from CREF, INFN, Universities and CERN
- EEE dual mission: cosmic ray experiment and scientific education
- 80 high schools, hundreds of teachers and students
- 50 tracking telescopes built at CERN and hosted in italian schools and laboratories



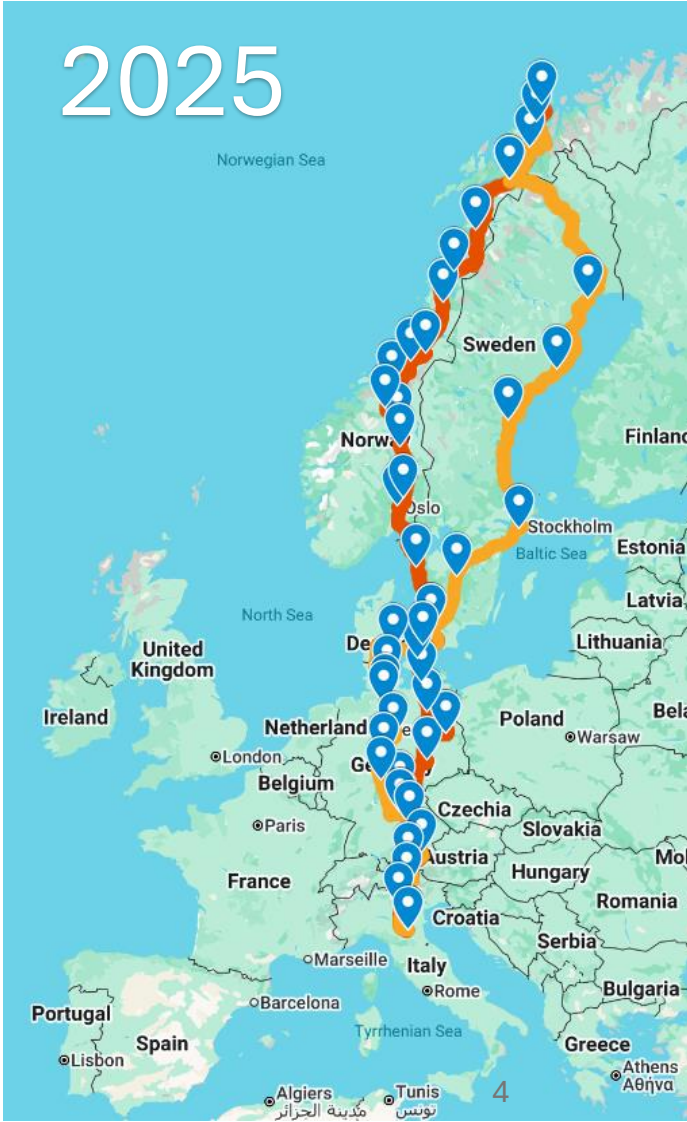
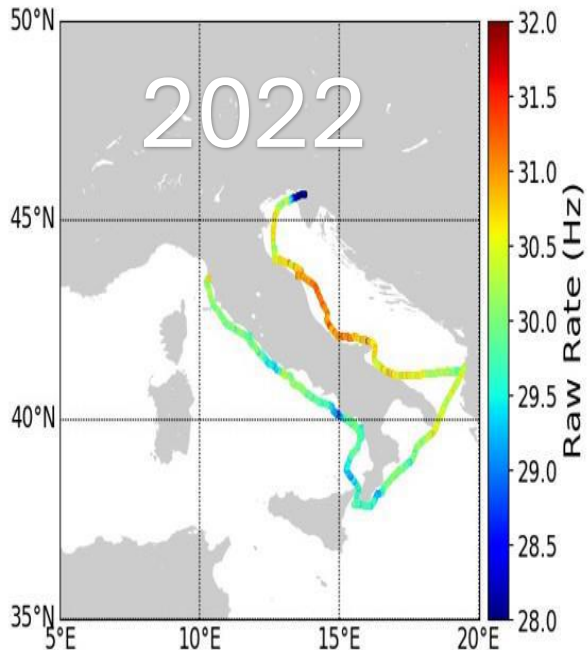
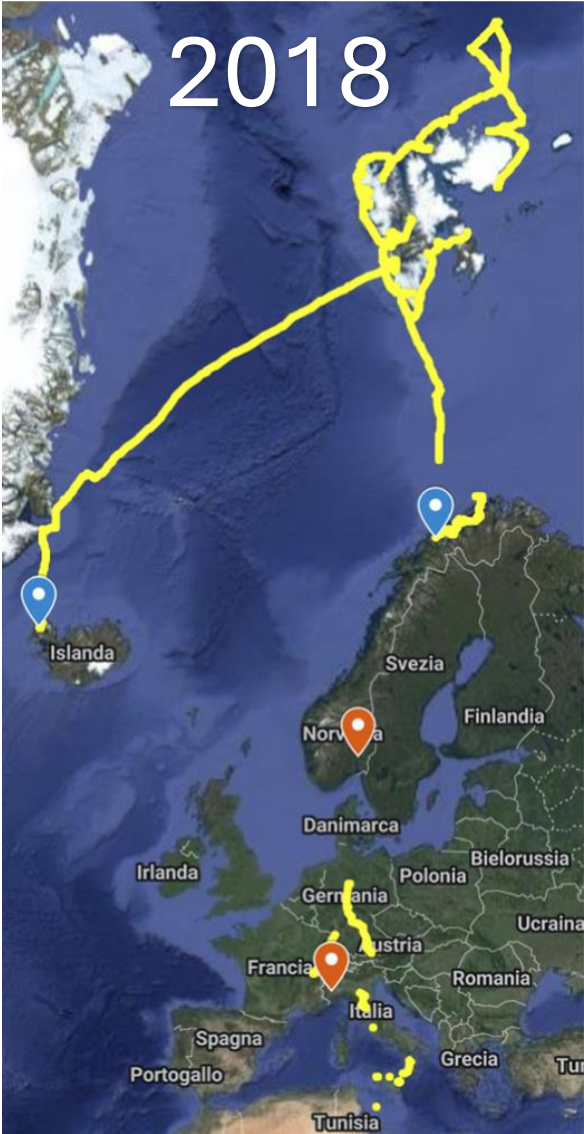
EEE: two models of telescopes



Timeline

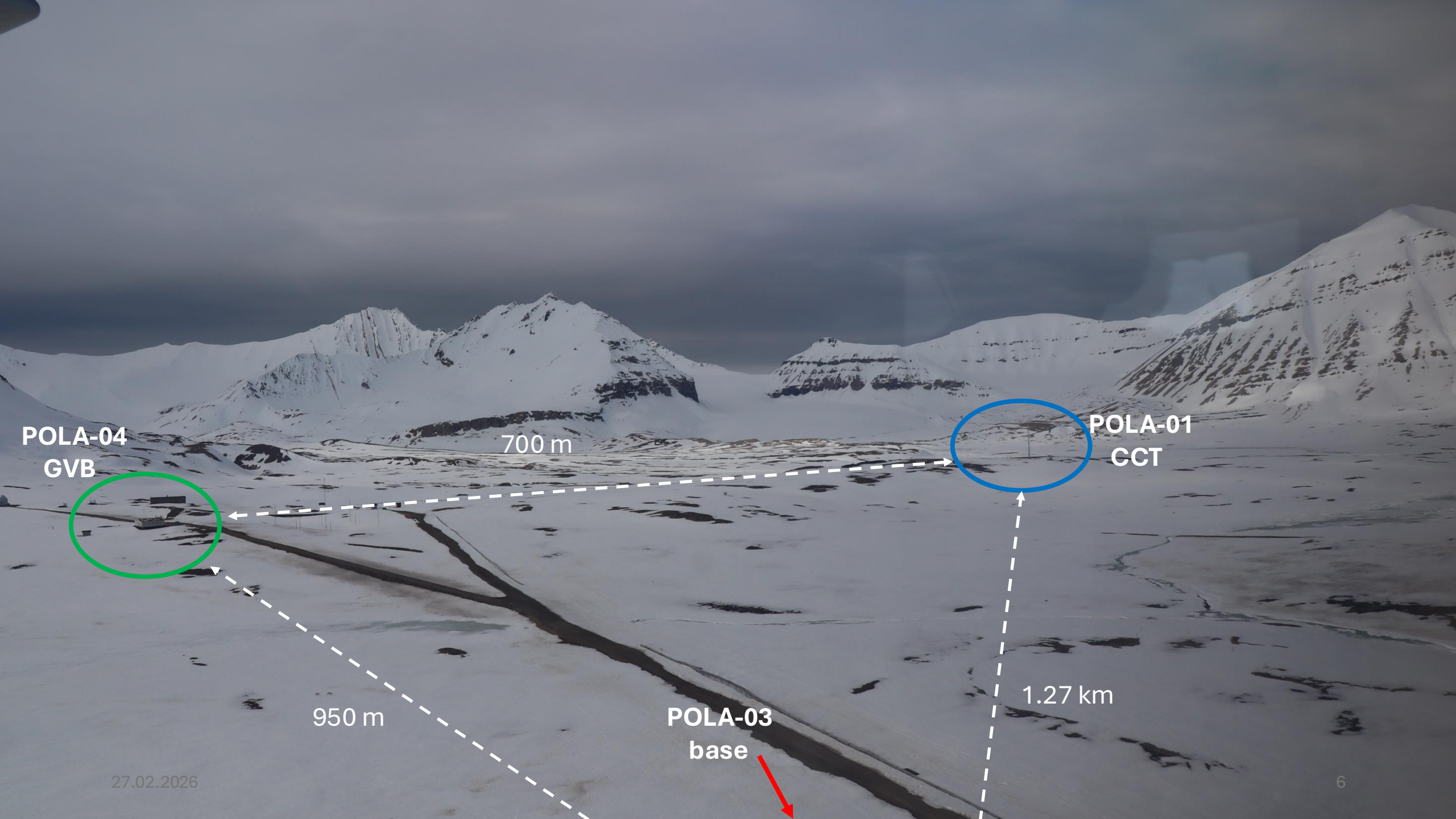


27.02.2026



The muon detectors at Ny-Ålesund





POLA-04
GVB

700 m

POLA-01
CCT

950 m

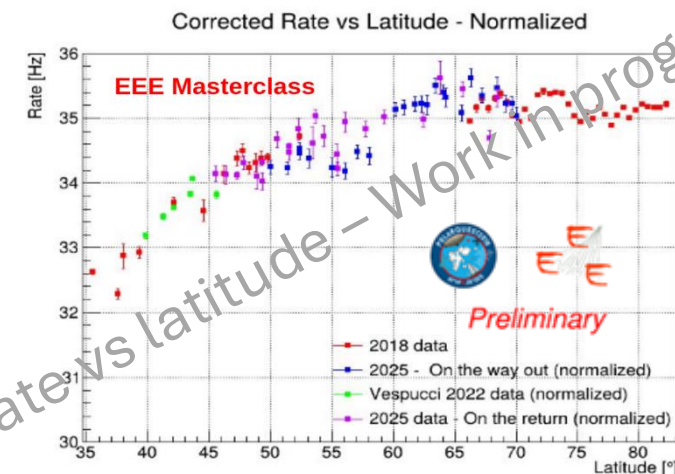
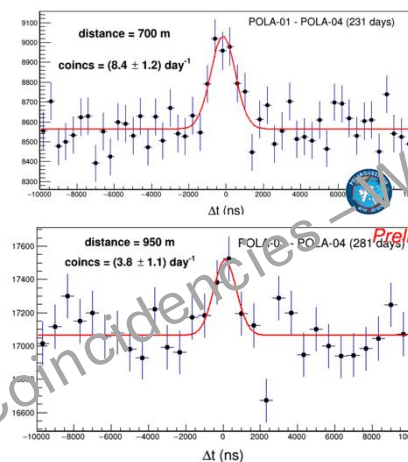
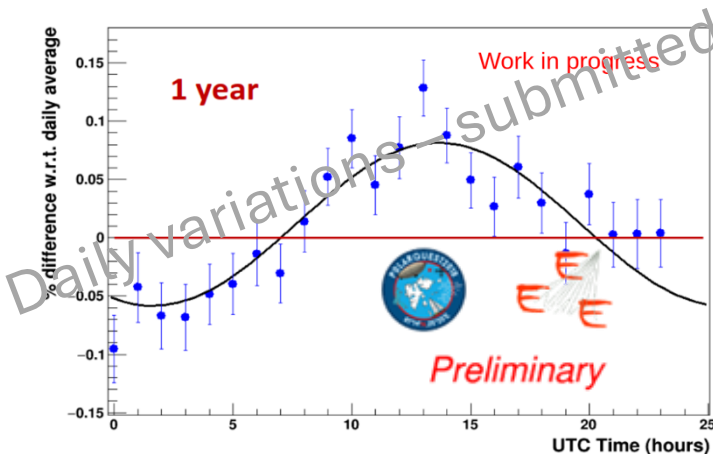
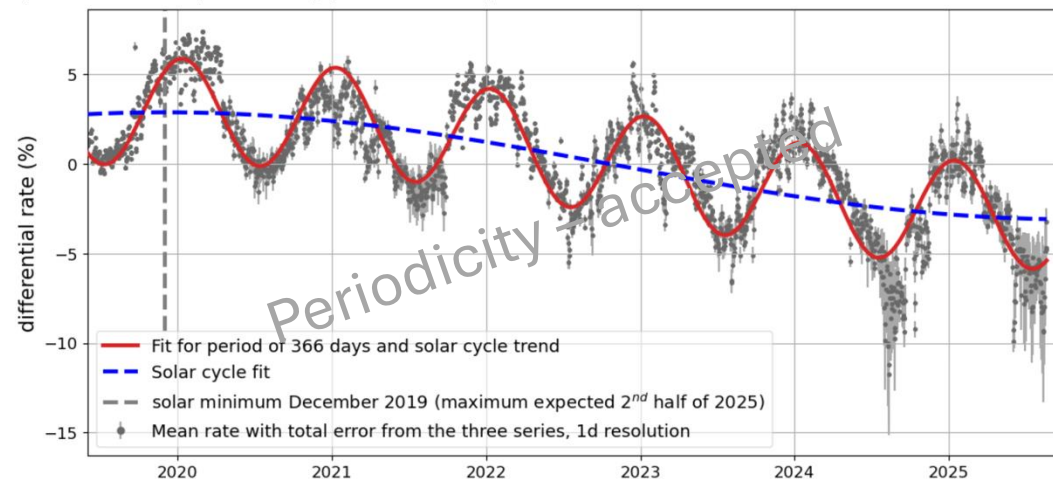
POLA-03
base

1.27 km

EEE POLA-R muon detectors papers

- Measurement of the cosmic-ray rate over the period 2019-2025 at very high latitude (78.9° N), accepted by The European Physical Journal C, 2026
- High latitude observation of the Forbush decrease during the May 2024 solar storms with muon and neutron detectors on Svalbard, Advances in Space Research (2025), 76(2025), pp.1225-1239
- High latitude muon and neutron observation of the Forbush decrease during the May 2024 solar storm, POS(ICRC2025)1356
- Measurement campaigns of the cosmic ray flux at different latitudes within the Extreme Energy Events Project, POS(ICRC2025)1245
- Annual quasiperiodicity in muon rate observed by PolarQuEEEst detectors at 79 N, Proceedings of the CRIS-MAC Conference, IOP Conf. Series, 2024
- Recent results from the PolarquEEEst measurement campaign at large geographical latitudes, Proceedings of Science (POS-ICRC2023) 232.
- Measurement of the cosmic charged particle rate at sea level in the latitude range 35° - 82° N with the PolarquEEEst experiment, The European Physical Journal C, volume 83, Article number: 293 (2023), doi:10.1140/epjc/s10052-023-11353-w
- Observation of the Rayleigh-Lamb waves generated by the 2022 Hunga-Tonga volcanic eruption with the POLA detectors at Ny Alesund, Scientific Reports 12(2022)19978.
- Latest results from the PolarquEEEst missions, Proceedings of Science POS (ICRC2021) 369.
- New high precision measurements of the cosmic charged particle rate beyond the Arctic Circle with the PolarquEEEst experiment, Eur. Phys. J. C (2020) 80:665, <https://doi.org/10.1140/epjc/s10052-020-8213-2>
- Results from the PolarquEEEst missions, 2020 J. Phys.: Conf. Ser. 1561 012001
- First results from PolarquEEEst, PoS (ICRC 2019) 371.

Ongoing analysis

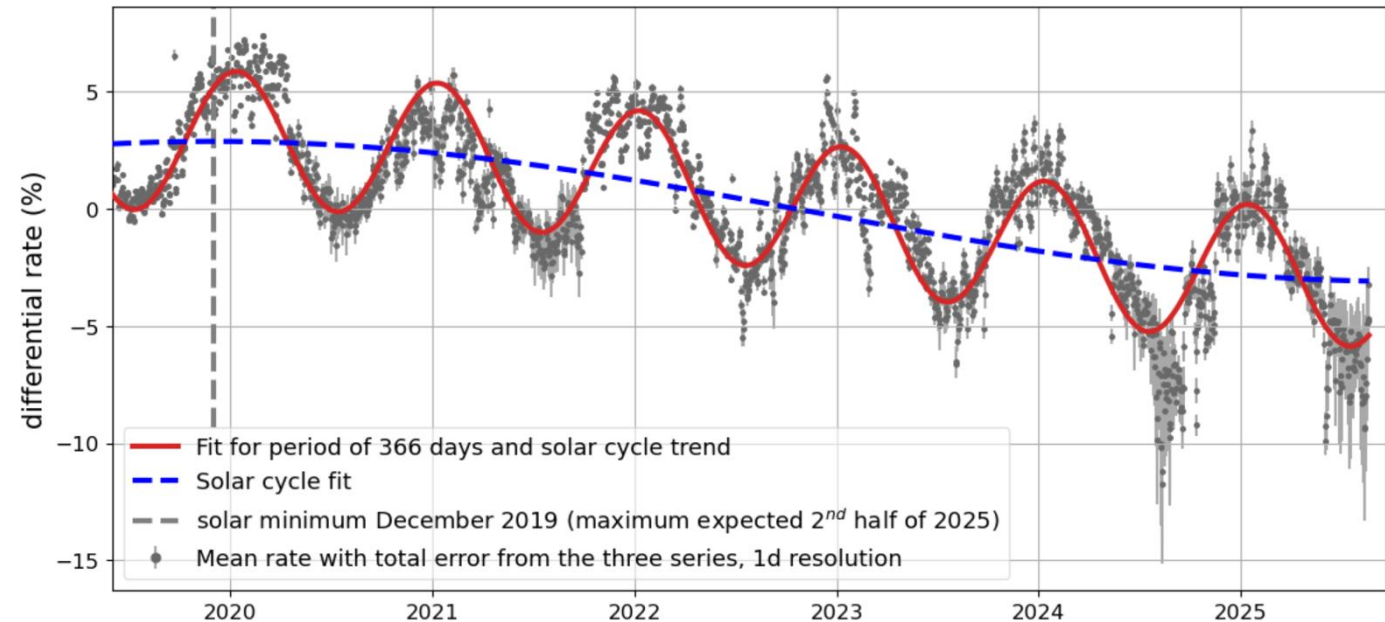
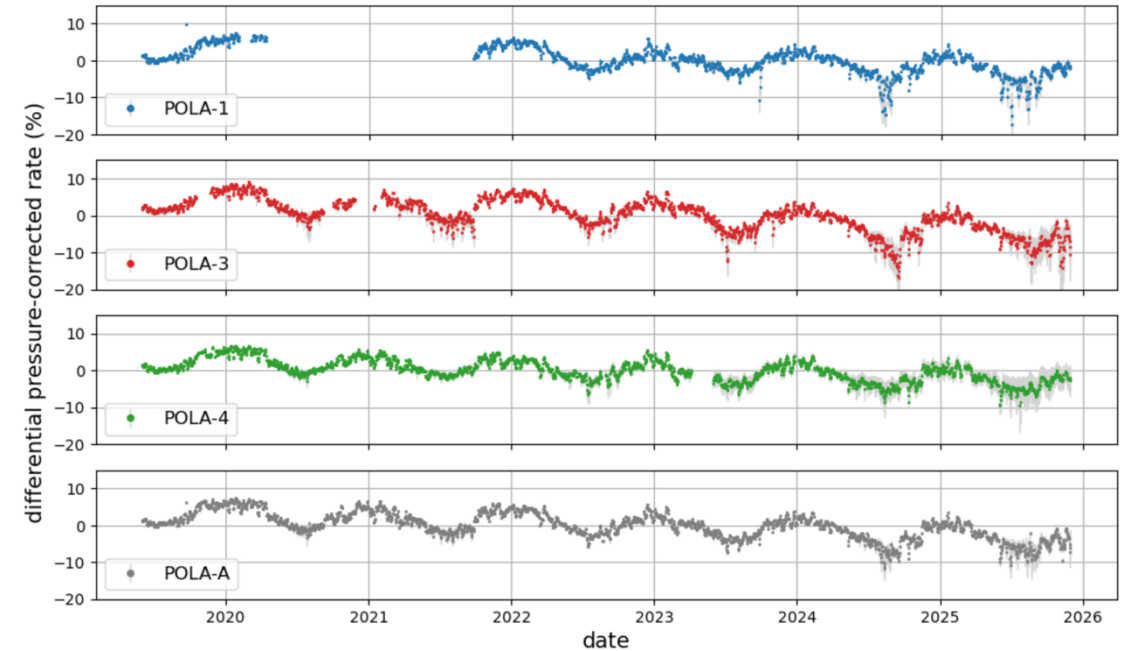


Muon rate periodicity

We analyzed more than six years of data and applied mathematical techniques to identify the underlying periodicities and frequency components. The dominant frequency emerged as the annual cycle, likely attributable to atmospheric effects.

The measured rates are sampled at one-minute intervals and selected to discard low-quality events. All rates are then corrected for atmospheric pressure and for pseudo-efficiency.

The rates reported here are not corrected for temperature.

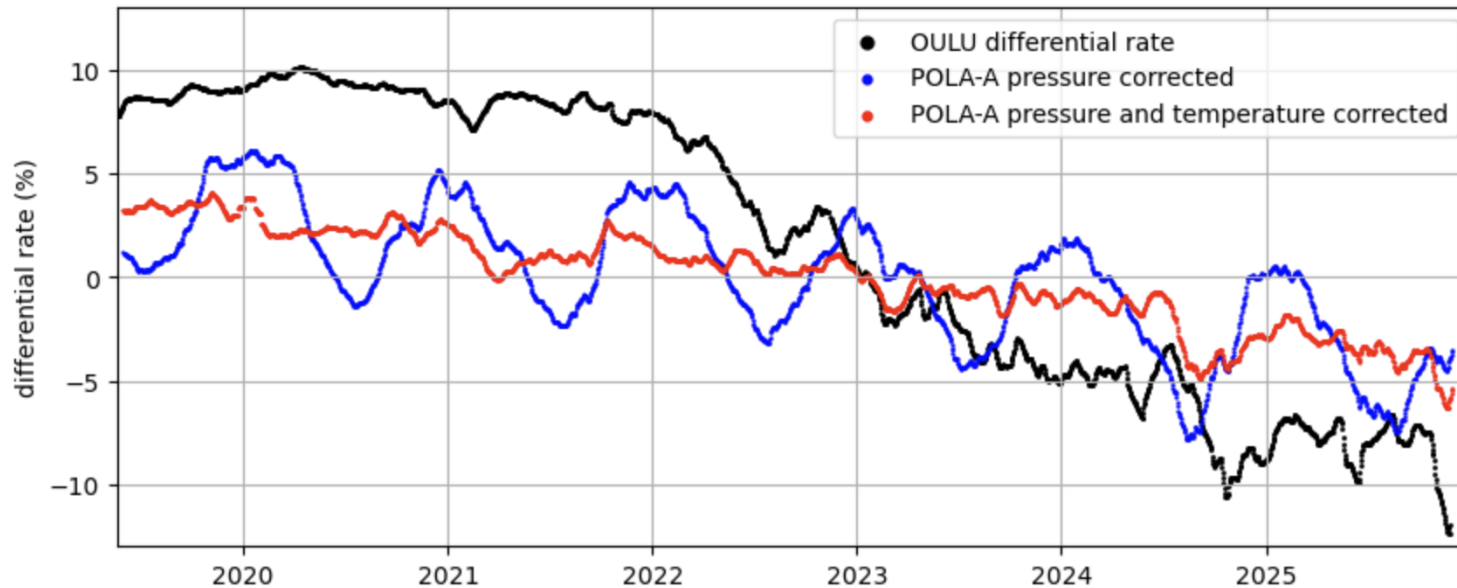
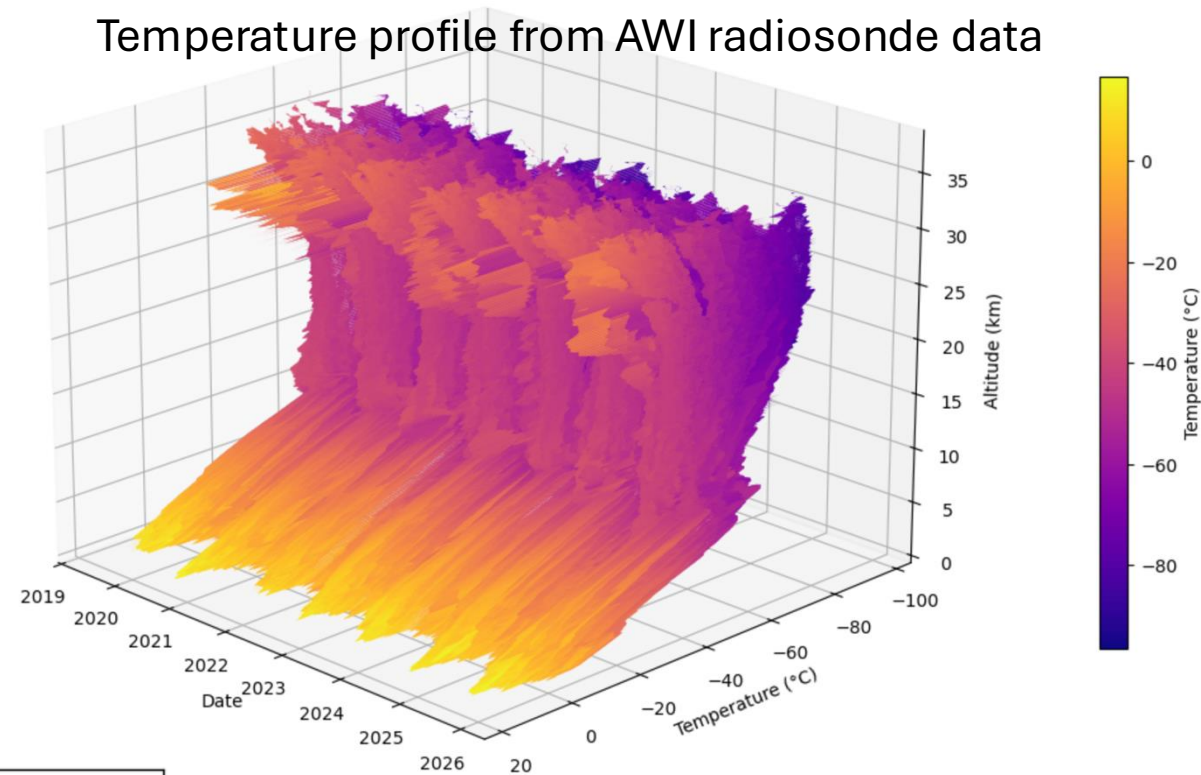


Muon rate and atmospheric temperature

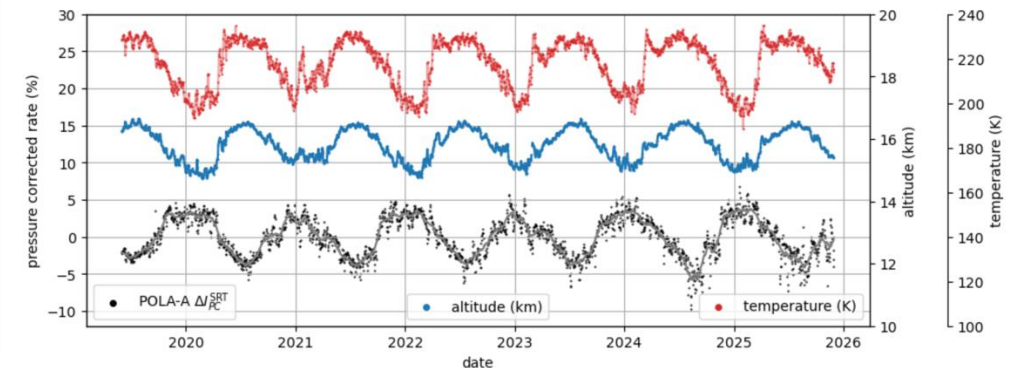
We analyzed the dependence of the muon rate on atmospheric temperature at various altitudes and pressure levels. We tested several models and developed a new one that is more adaptable to different local conditions.

By subtracting from the rate the component that depends on temperature, we observed that the annual periodicity disappears.

Temperature profile from AWI radiosonde data



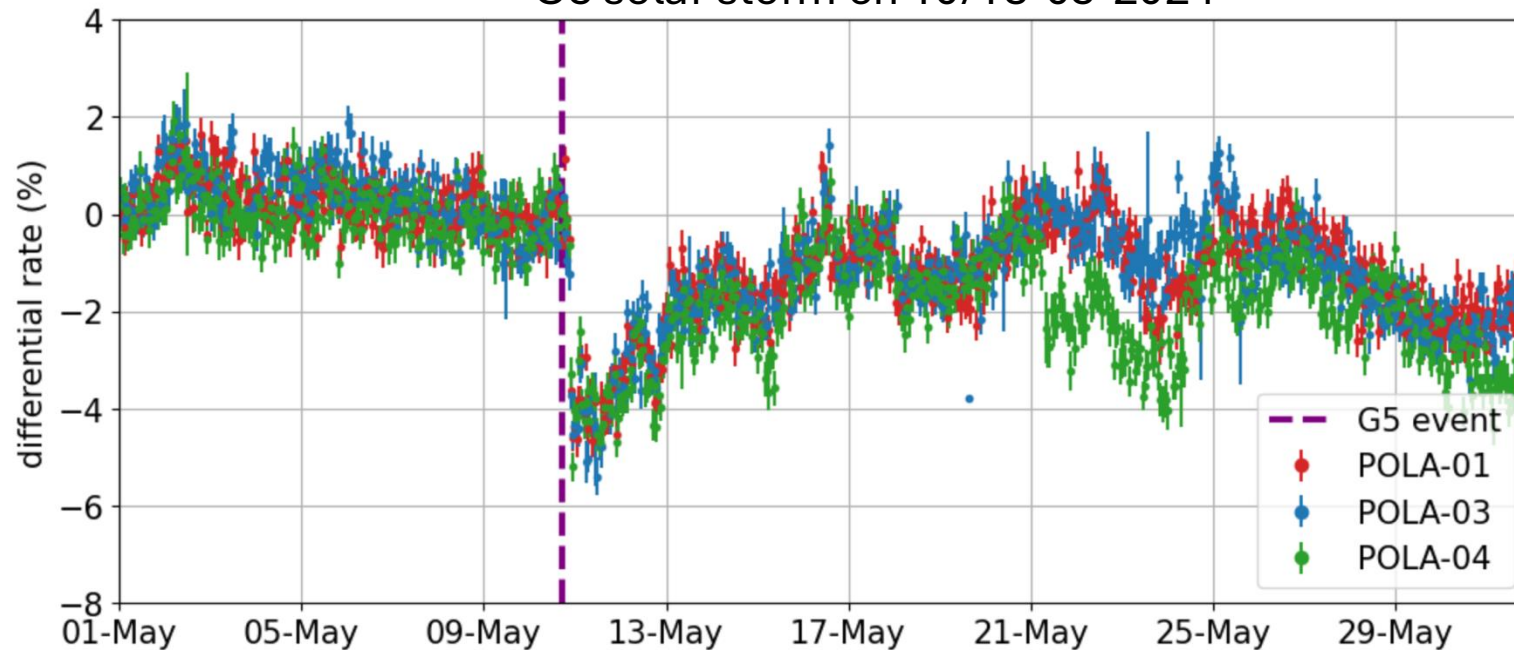
Ex. anti-correlation between rate and temperature



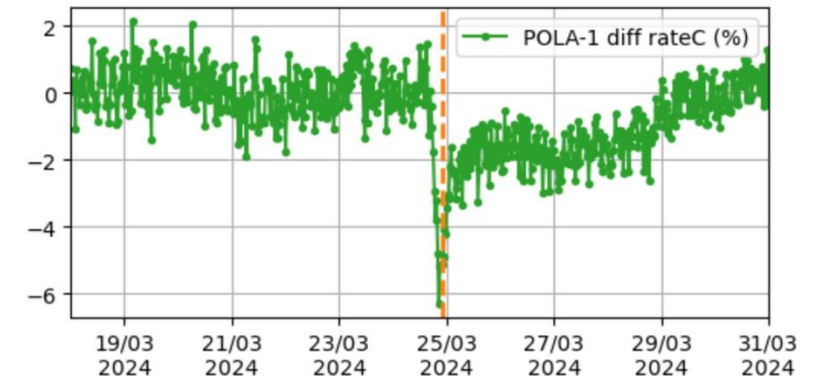
Forbush decrease seen by POLA-R muon detectors

POLA-R muon detectors measure rate decreases of about 4% during Forbush decrease events

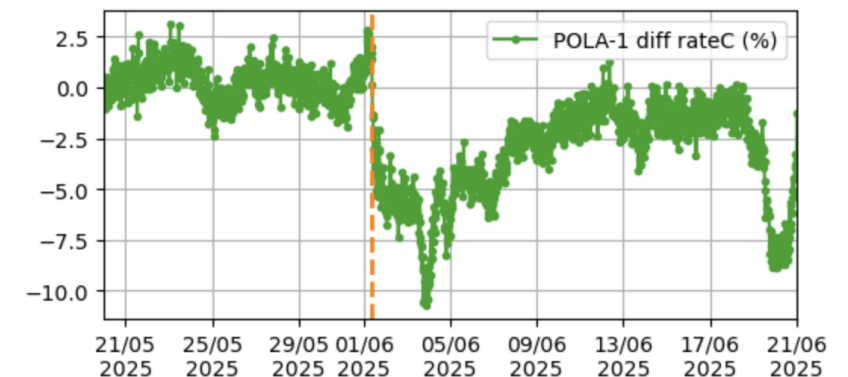
G5 solar storm on 10/13-05-2024



G4 solar storm on 24-03-2024



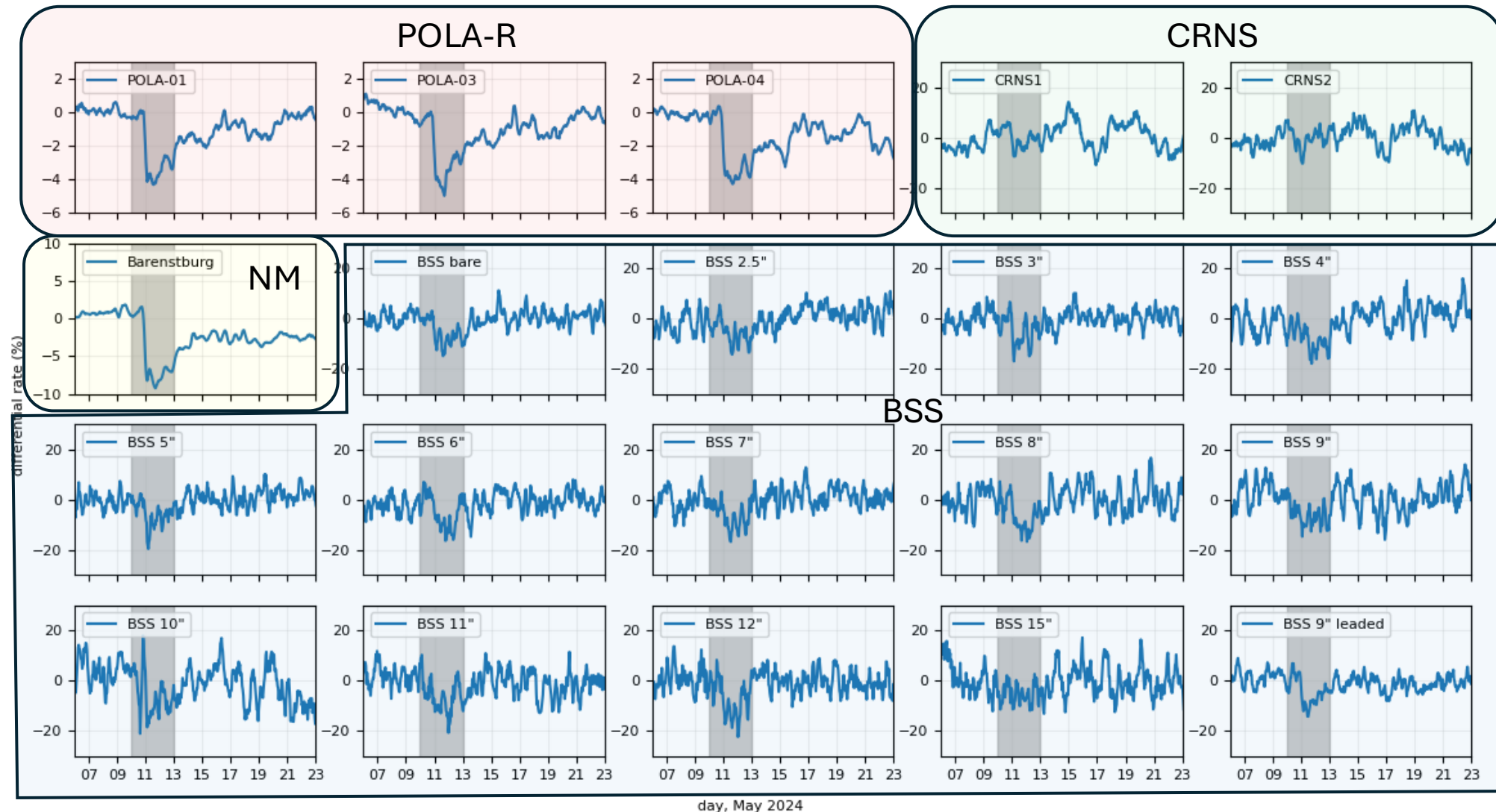
G4 solar storm on 01-06-2025



Forbush 10 May 2024

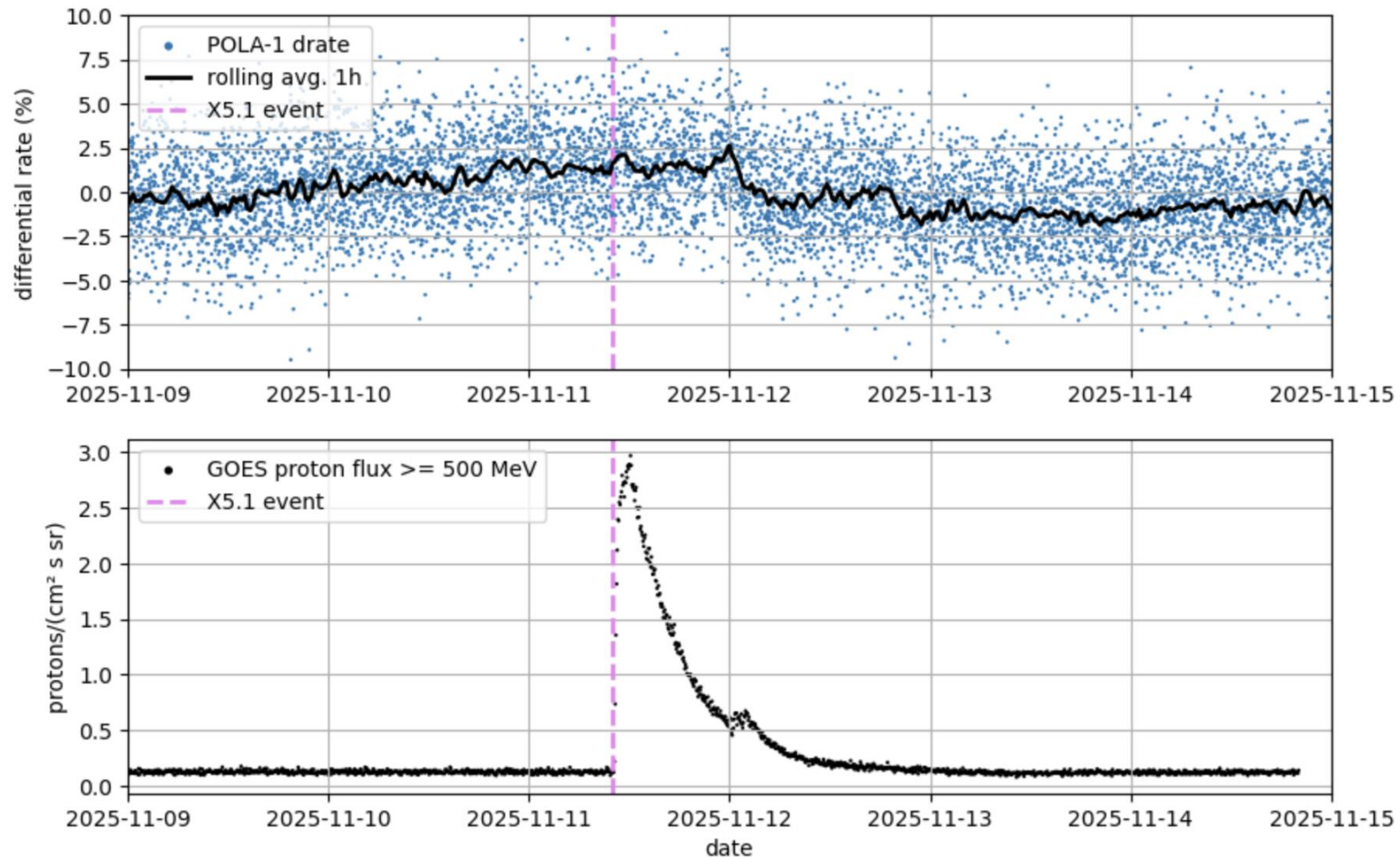
seen by POLA-R, BSS and SVEN at Ny-Ålesund

High latitude observation of the Forbush decrease during
the May 2024 solar storms with muon and neutron detectors on Svalbard
by F. Riggi, L. Hartle, et al., Published on Advances in Space Science
<https://doi.org/10.1016/j.asr.2025.05.023>



Solar event on 11/11/2025

During GLE77, the rates measured by our muon detectors do not show a significant increase beyond normal statistical fluctuations.



Conclusions

With POLA-R muon detectors and missions, the EEE network spans over 4800 km, between 35°N and 82°N.

We recorded 10^{10} events in almost 7 years. Several analysis are ongoing.

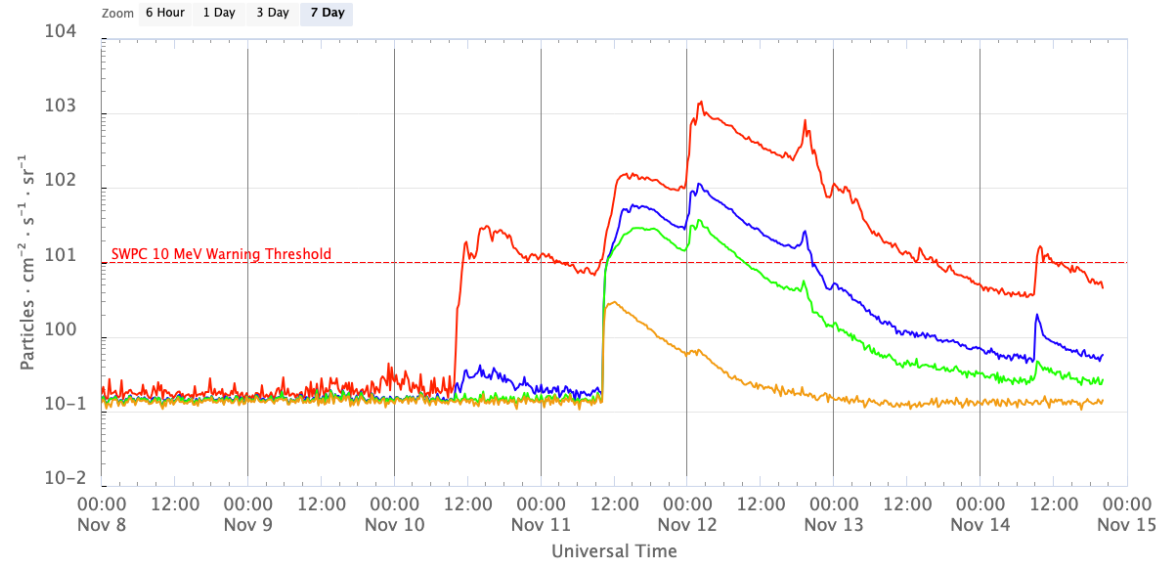
POLA-R muon detectors measure rate decreases of about 4% during Forbush decrease events, whereas they have not shown significant increases in the case of GLE events.

The installation at the Ny-Ålesund Research Station has facilitated the development of collaborations with scientists from different institutions and countries, aimed at investigating correlations with environmental, solar, and cosmological parameters measured in a completely independent manner.

backup slides

More plots on GLE77

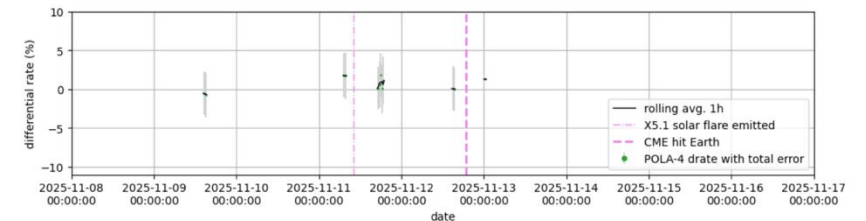
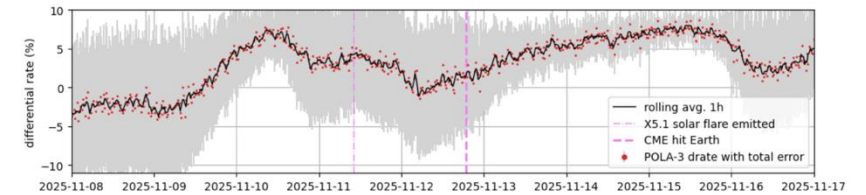
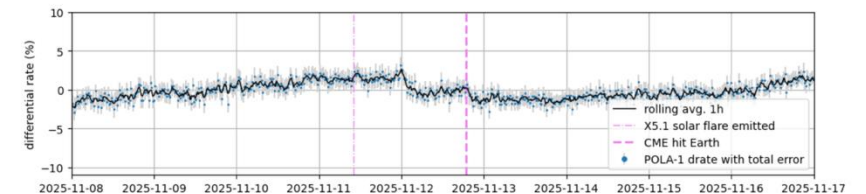
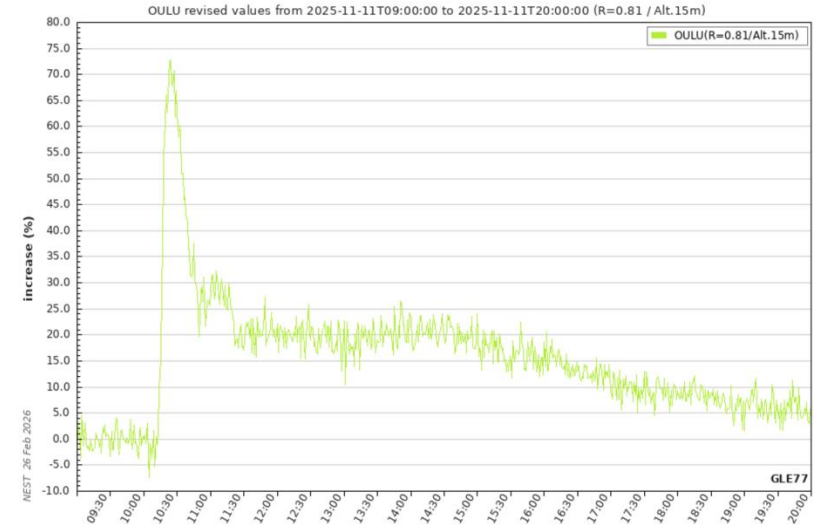
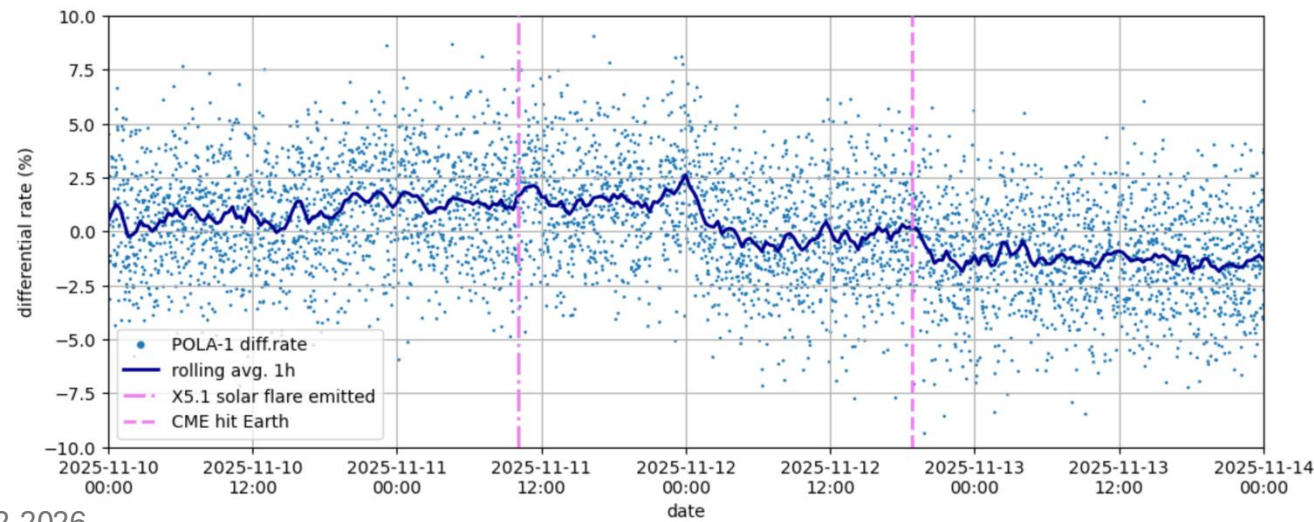
GOES Proton Flux (5-minute data)



Updated 2025-11-14 20:05 UTC

GOES-18 ≥ 10 MeV GOES-18 ≥ 50 MeV GOES-18 ≥ 100 MeV GOES-18 ≥ 500 MeV

Space Weather Prediction Center



POLA vs OULU

