The Forbush Effect

ICD 2024

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1. INTRODUCTION

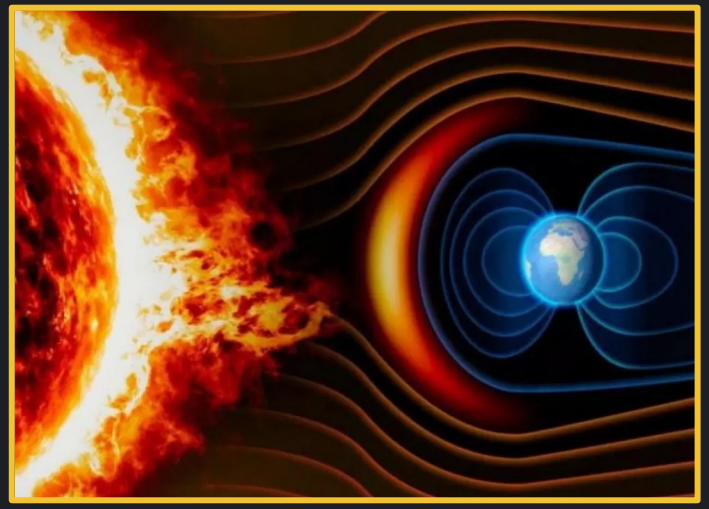
In this analysis we study and compare variations in muon flux during the **solar flare event beginning on May 10, 2024.**

Given data

- The rates of 8 different detectors between the **15th of April 2024** and the **15th of May 2024**
- Rates were expressed in both **HitEvents** and **TrackEvents**
- **Pressure**

Data analysis

1. Pressure correction
2. Correlations between rate decrease and Solar Flare
3. Final remarks and discussion



02. FORBUSH EFFECT

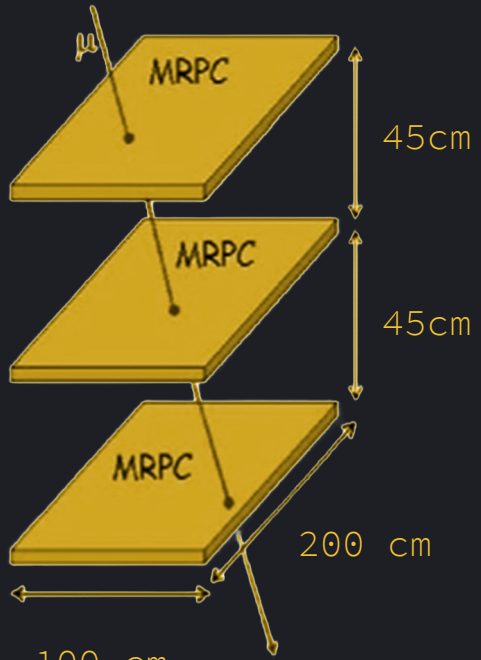
The **Forbush Effect** is a temporary decrease in the rate of cosmic rays reaching the Earth.

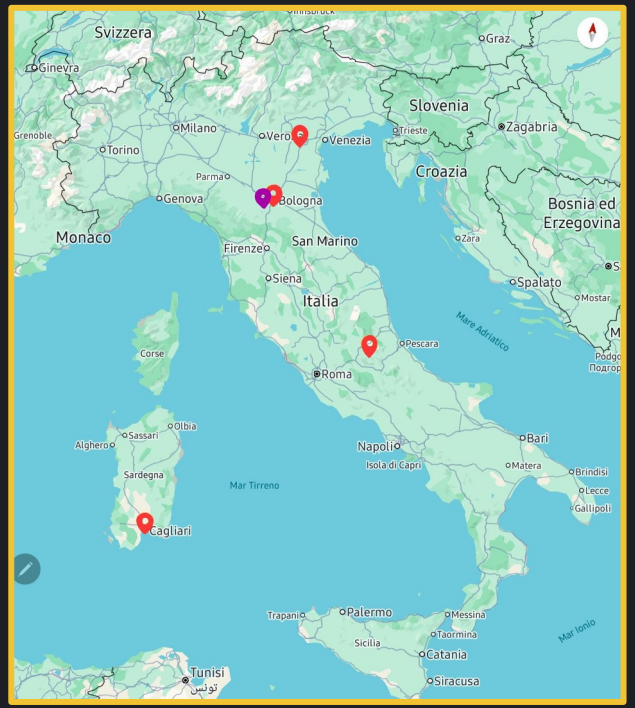
This occurs because of:

- **Magnetic shielding and cosmic ray flux decrease**
- **Deflection of cosmic rays**
- **Shock waves and turbulence**

03. DETECTORS

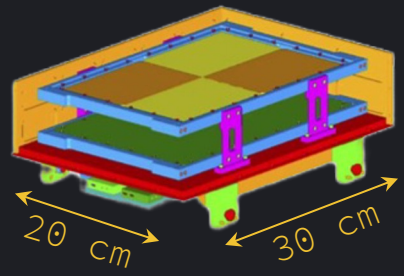
MRPC





POLA

Scintillator



04. ANALYSIS

- **Barometric correction** of *RateHit* and *RateTrack*

$$RateHit_{Corr} = RateHit_{nonCorr} \cdot e^{\alpha_{Hit} \cdot (P_{mis} - P_{ref})}$$

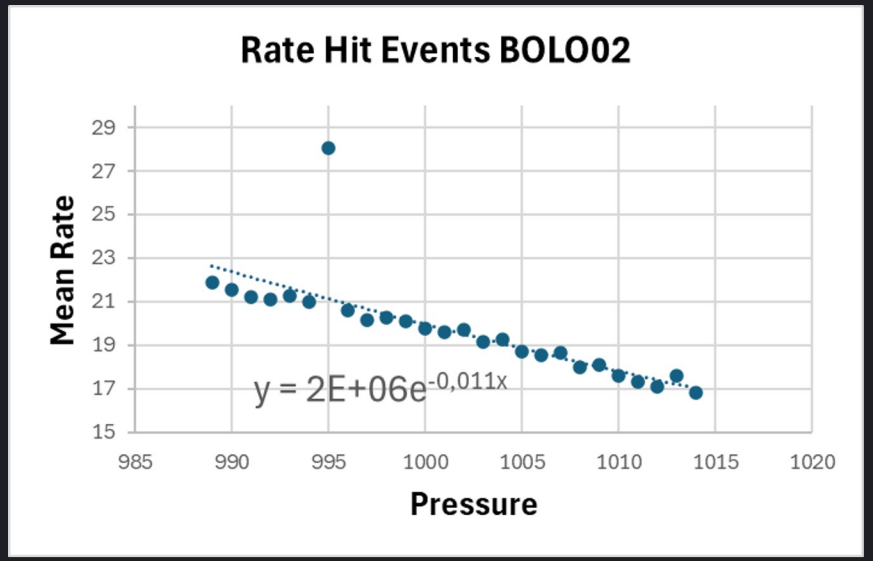
$$RateTrack_{Corr} = RateTrack_{nonCorr} \cdot e^{\alpha_{Track} \cdot (P_{mis} - P_{ref})}$$

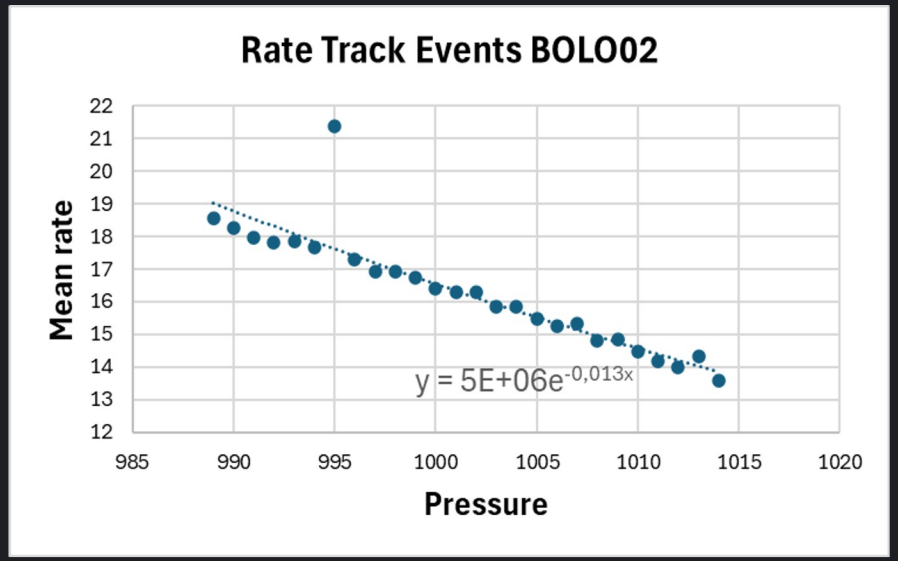
P_mis: *pressure corresponding to the average rate;*
P_ref: *reference pressure of 1000 mbar;*
α: *barometric coefficient*

- Average *RateHit* and *RateTrack*, with and without barometric correction, in two-hour time intervals
- **Normalization of rates** comparing data sets

$$RateNorm = \frac{average\ rate\ in\ time\ interval}{average\ rate\ in\ all\ time\ intervals}$$

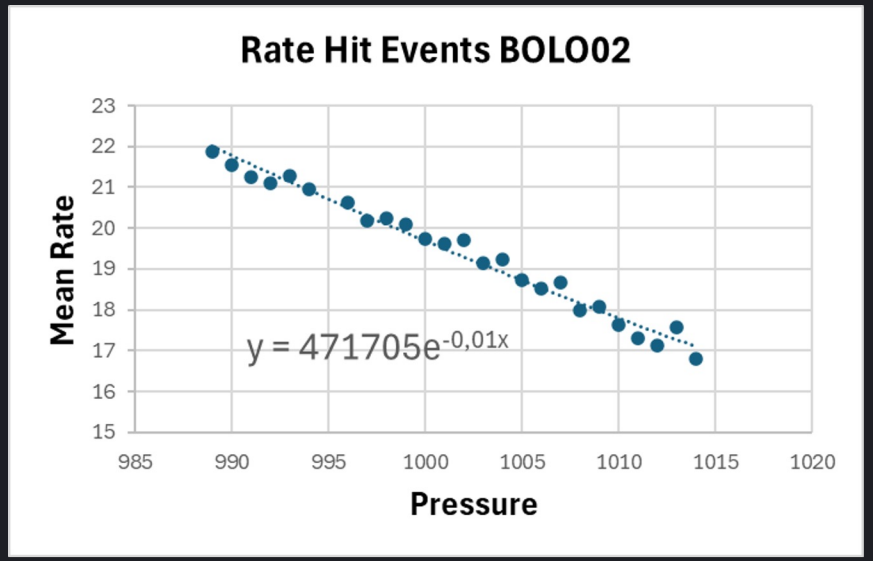
04. BAROMETRIC CORRECTION

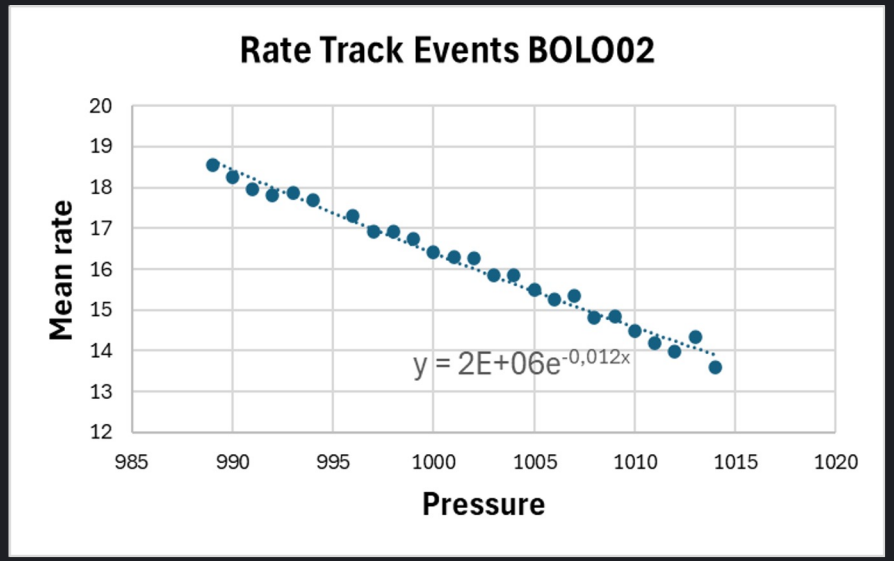




HitEvents and TrackEvents have a different barometric coefficient. The data provided show some spurious values: these were removed from our later analysis.

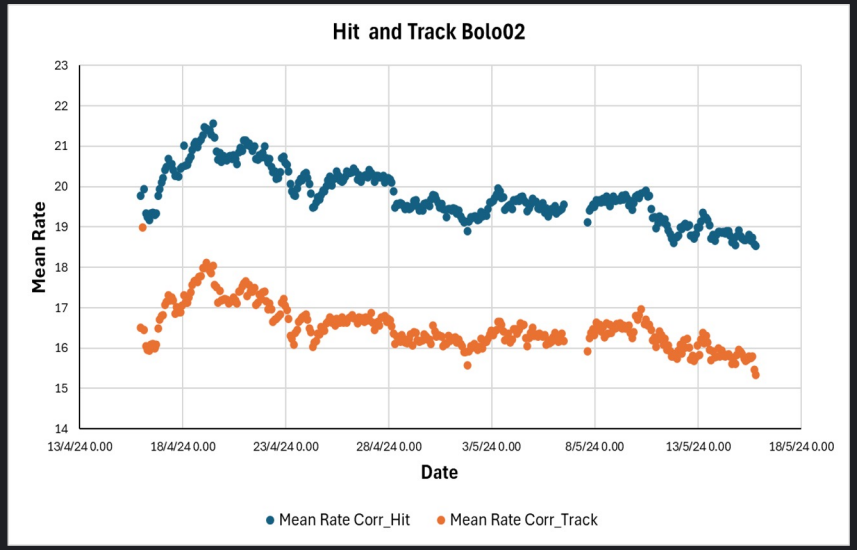
04. BAROMETRIC CORRECTION



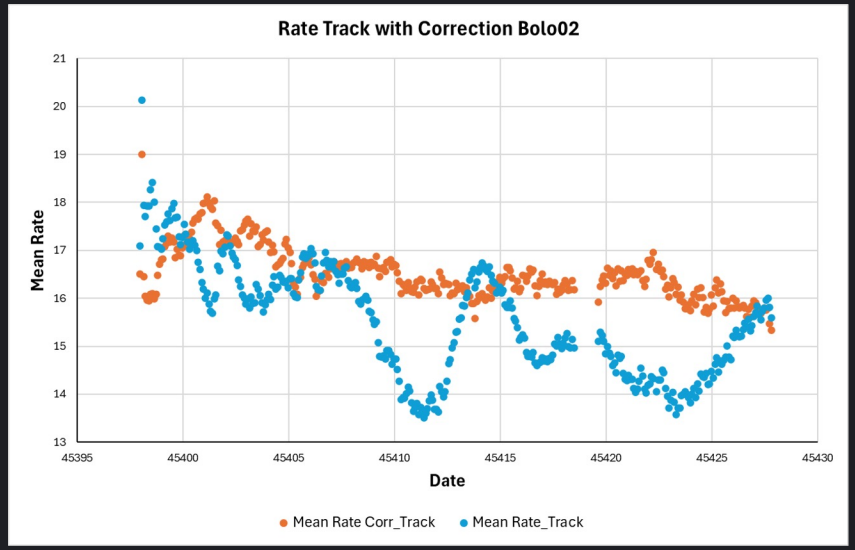


By removing the spurious values we obtained a different barometric coefficient that we used for our analysis

05. HIT / TRACK GRAPHS AND CORRECTION



Analysis of the data of both RateHit and RateTrack and compared the results.

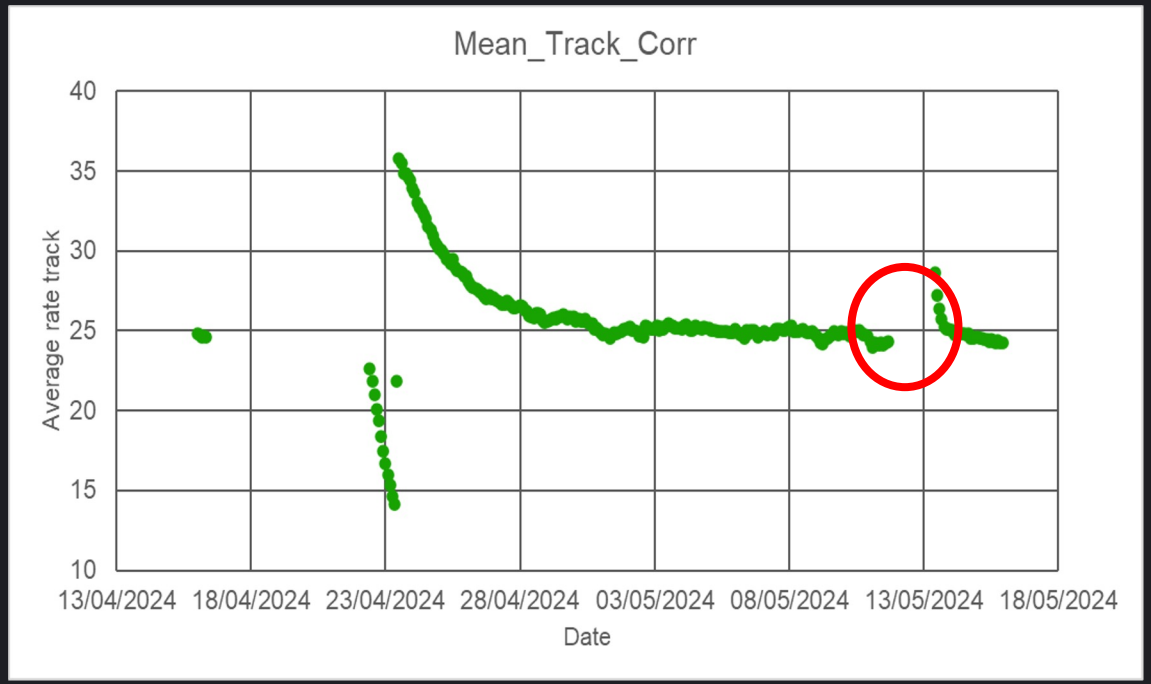


Comparison between RateTrack with and without barometric correction.

As a result we continued the analysis with RateTrack Corrected.

05. GRAPHS - CAGLIARI

We did not consider data of Cagliari's MRPC due to missing data (particularly from 11/05 to 13/05) and anomalies during the time of analysis.

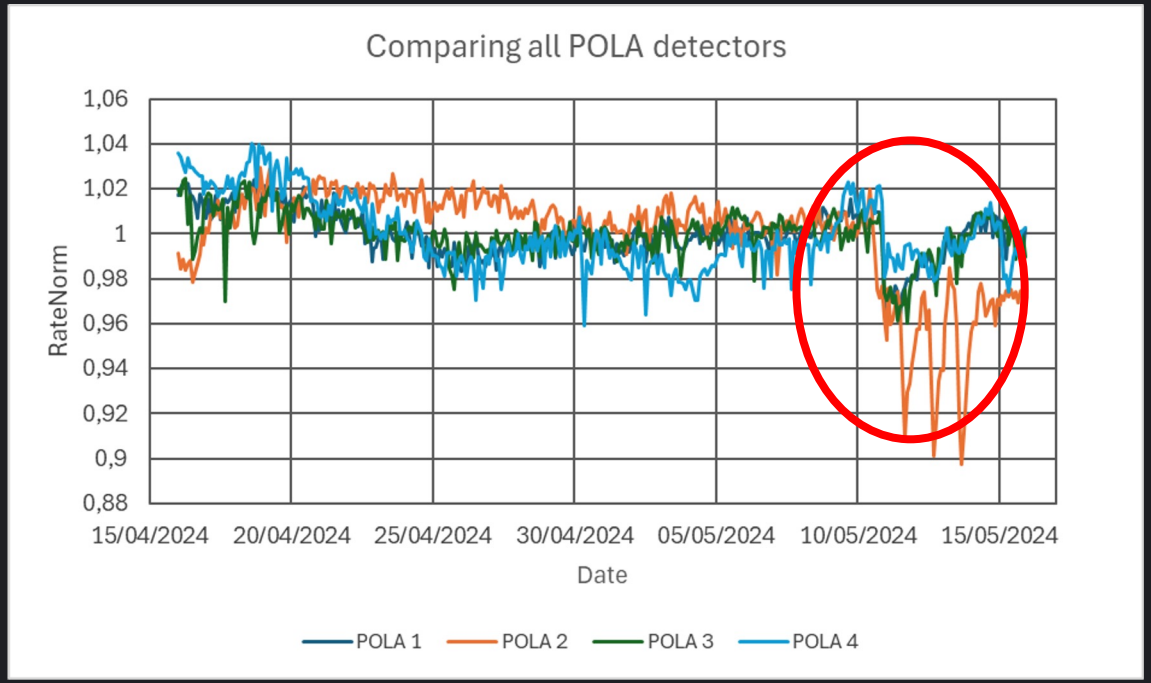


05. GRAPHS - POLA detectors

It is important to note that all the graphs show a sharp decrease (4%) in the rate of events between 11/05 and 13/05

POLA01, POLA03, POLA04 (Ny-Ålesund) follow a similar trend.

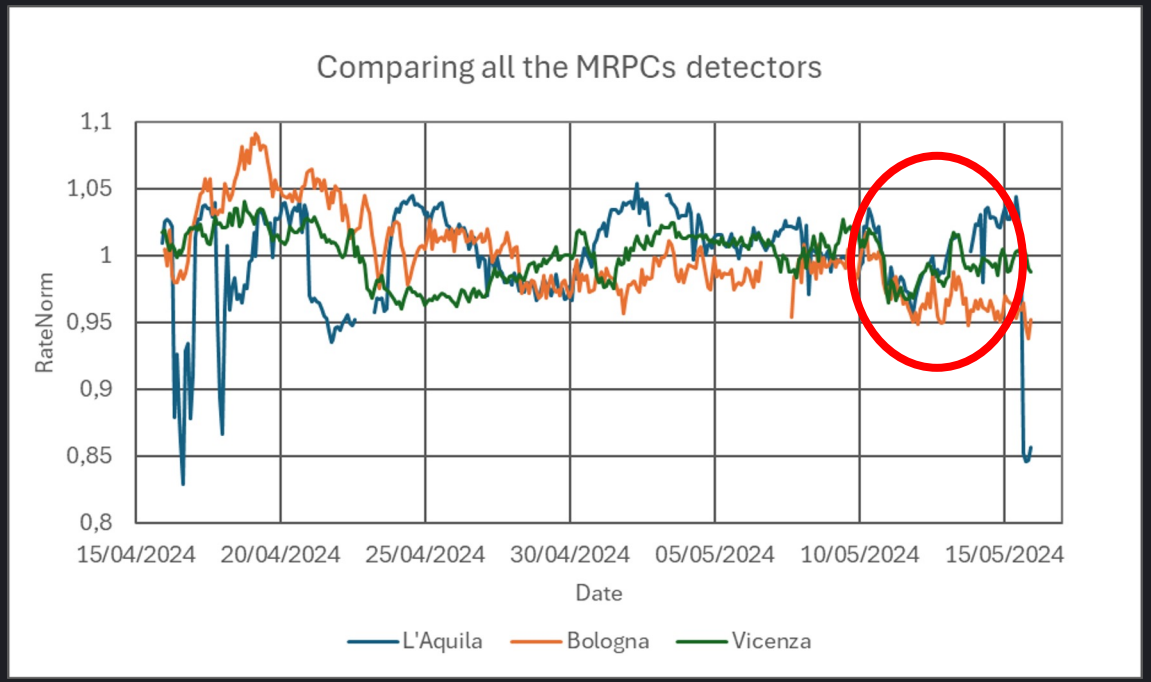
POLA02 (Bologna, in orange) shows more significant fluctuations around the negative peak.



05. GRAPHS - MRPC detectors

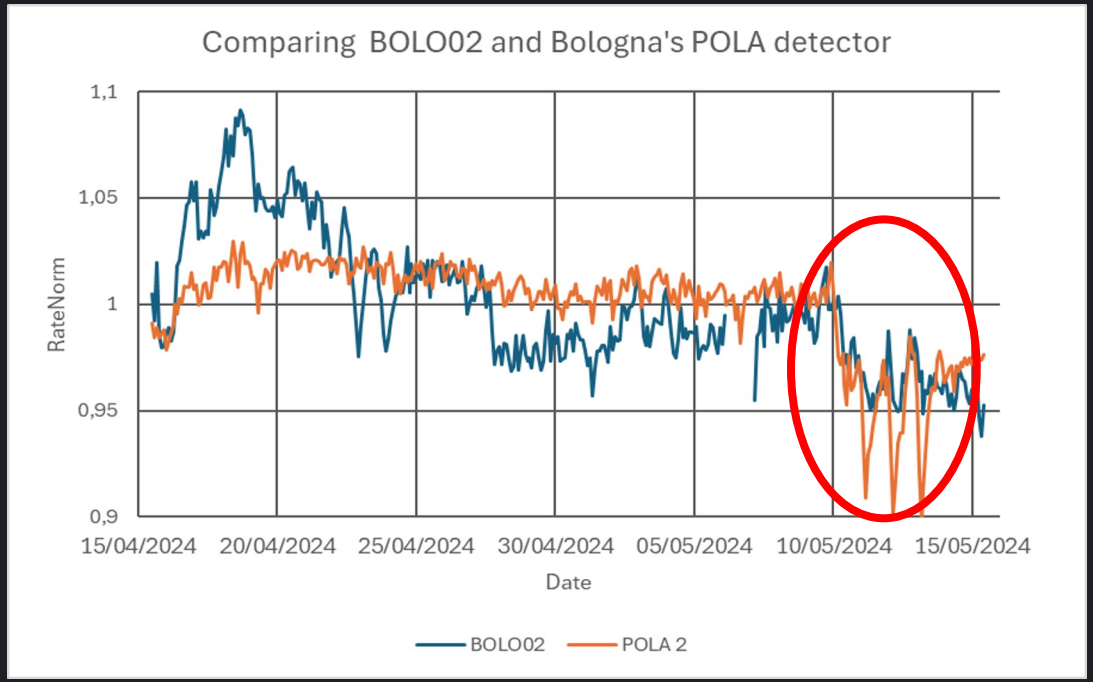
It is important to highlight that all the graphs show the same decrease (4%) in the rate of events between 11/05 and 13/05.

MRPC detectors show wider fluctuations than POLA detectors.

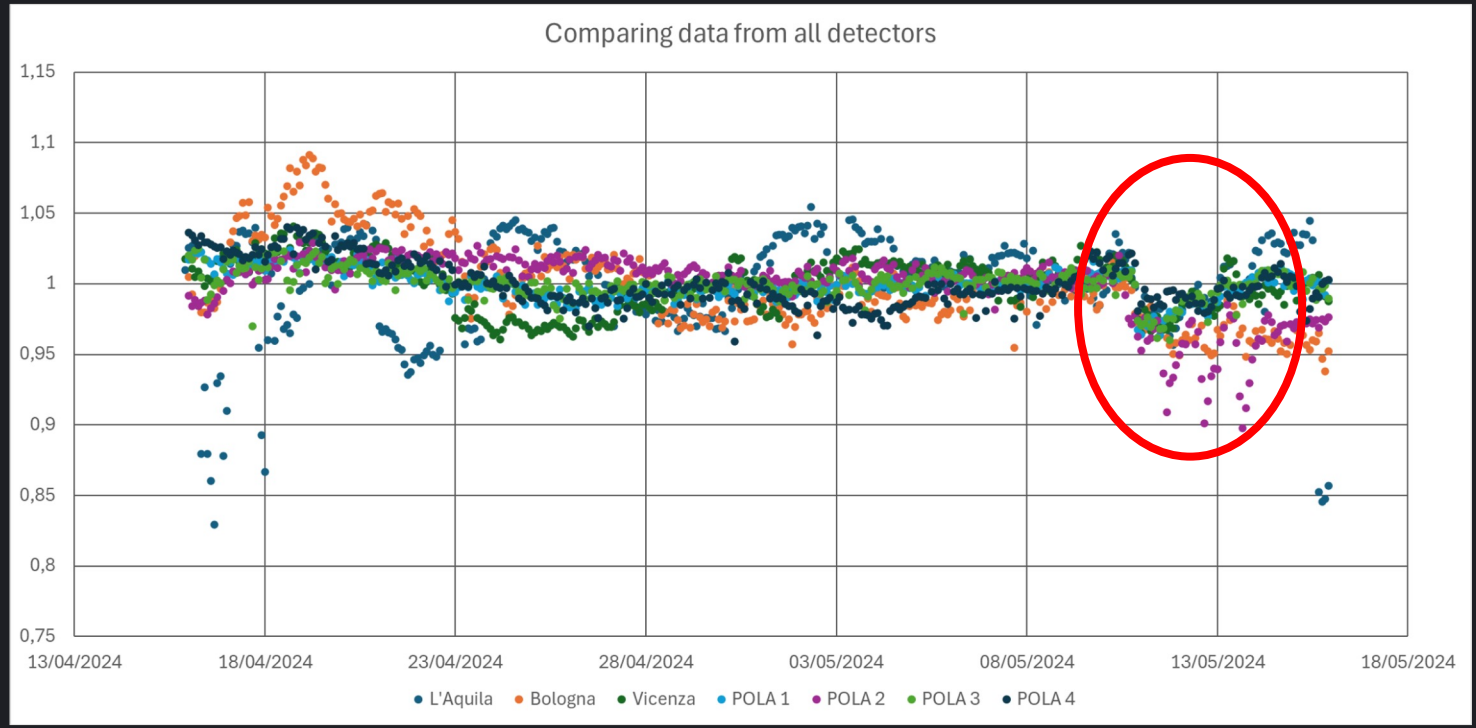


05. GRAPHS - BOLOGNA

Even in this case, it is important to highlight that both detectors share some negative peaks during the solar flare period, although POLA02 shows wider fluctuations around the negative peak.



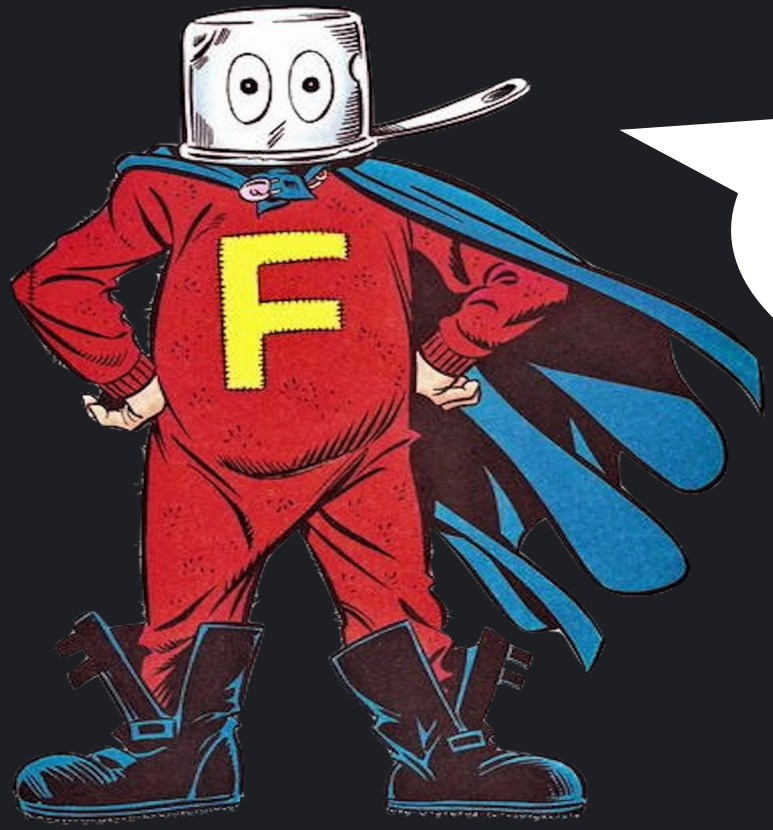
06. DATA COMPARISON



Graph comparing the percentage change of all the data

07. CONCLUSIONS

- No matter the type (MRPC or POLA) or location, all detectors show the same decrease (4%) in muon flux during the solar flare period (10/05-13/05)
- RateHit and RateTrack data show the same decrease in muon flux, even though RateHit's data is shifted upwards on the graph
- Rates fluctuate less with barometric correction than without correction
- The fluctuations of BOLO02 were probably affected by weather conditions (e.g. temperature, precipitations,...).
  We will investigate this correlation in the future



Hi! I’m Forbush Man! Thank you for your attention. It was a pleasure shielding you from cosmic rays!