Extreme Energy Events
Science inside Schools

**LICEO STATALE
REGINA MARGHERITA
SALERNO
5S & 3S**

CENTRO FERMI

MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI

POLA-01, POLA-03, POLA-04 DETECTORS AND SEASONAL MUON FLUX: DATA ANALYSIS

**Teacher: Marilena Loia
Student Presenters: Sara Avagnale, Luana De Rosa, Salvatore Negro**

ABSTRACT

On the 28th & 29th October 2020 the Regina Margherita High School, participated in the analysis of data collected from three POLA telescopes (POLA-01, POLA-03 & POLA-04) between July 2019 and July 2020 with the aim of studying the rate of muons over time and the valuation of the possible seasonal effects: variations in the flux of muons in relation to the changes in atmospheric conditions (pressure and temperature). The results are presented in the following report.

SET UP OF THE EXPERIMENT

The set up consists of three POLA detectors, small telescopes made from sparkling planes and photomultipliers (SiPM). The team participants of 24 students and one teacher collaborated with each other both online and in the classroom on the 28th October 2020. There were four groups with six students in each group. Each group had followed the instructions provided by the Centro Fermi to obtain the data for completing analysis of the data, working to three sets of available measures (Figures 1,2).
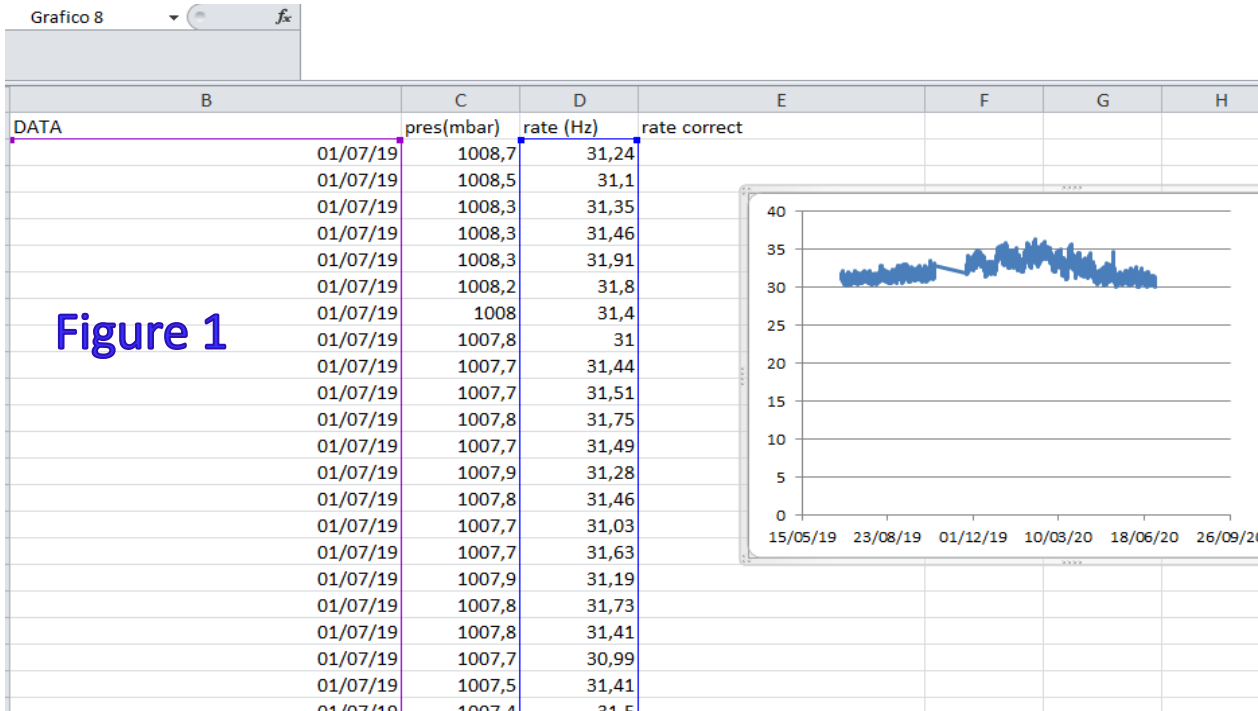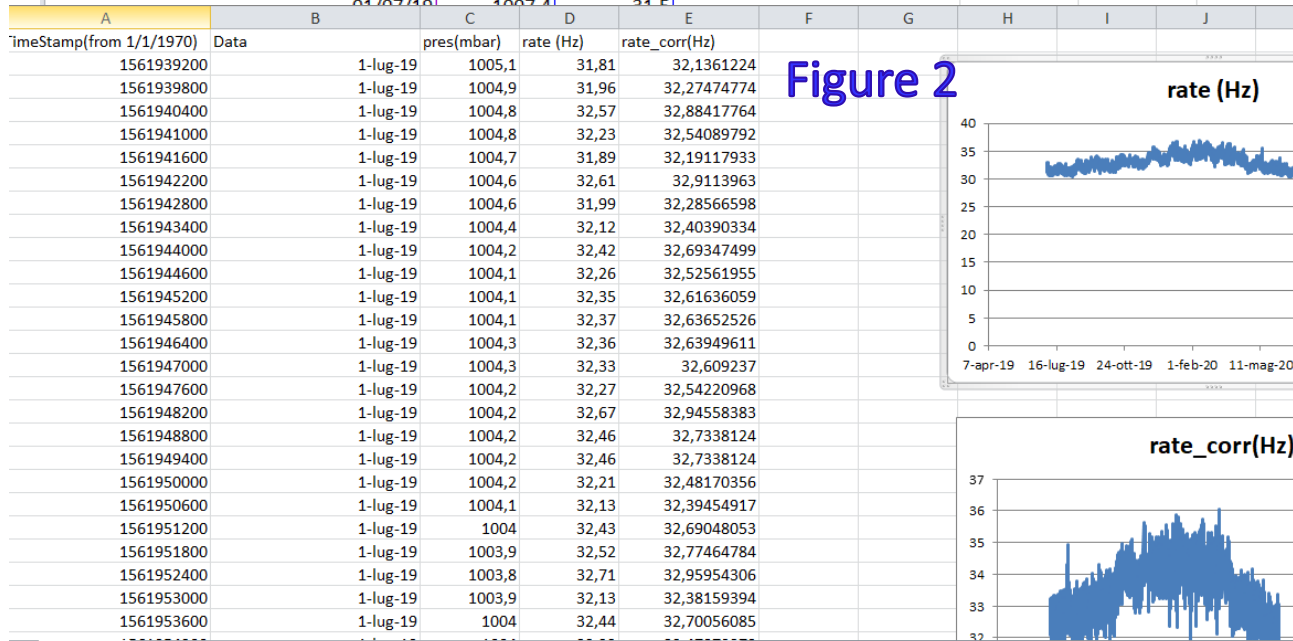
Figure 1

DATA	pres(mbar)	rate (Hz)	rate correct
01/07/19	1008,7	31,24	
01/07/19	1008,5	31,1	
01/07/19	1008,3	31,35	
01/07/19	1008,3	31,46	
01/07/19	1008,3	31,91	
01/07/19	1008,2	31,8	
01/07/19	1008	31,4	
01/07/19	1007,8	31	
01/07/19	1007,7	31,44	
01/07/19	1007,7	31,51	
01/07/19	1007,8	31,75	
01/07/19	1007,7	31,49	
01/07/19	1007,9	31,28	
01/07/19	1007,8	31,46	
01/07/19	1007,7	31,03	
01/07/19	1007,7	31,63	
01/07/19	1007,9	31,19	
01/07/19	1007,8	31,73	
01/07/19	1007,8	31,41	
01/07/19	1007,7	30,99	
01/07/19	1007,5	31,41	

Figure 2

TimeStamp(from 1/1/1970)	Data	pres(mbar)	rate (Hz)	rate_corr(Hz)
1561939200	1-lug-19	1005,1	31,81	32,1361224
1561939800	1-lug-19	1004,9	31,96	32,27474774
1561940400	1-lug-19	1004,8	32,57	32,88417764
1561941000	1-lug-19	1004,8	32,23	32,54089792
1561941600	1-lug-19	1004,7	31,89	32,19117933
1561942200	1-lug-19	1004,6	32,61	32,9113963
1561942800	1-lug-19	1004,6	31,99	32,28566598
1561943400	1-lug-19	1004,4	32,12	32,40390334
1561944000	1-lug-19	1004,2	32,42	32,69347499
1561944600	1-lug-19	1004,1	32,26	32,52561955
1561945200	1-lug-19	1004,1	32,35	32,61636059
1561945800	1-lug-19	1004,1	32,37	32,63652526
1561946400	1-lug-19	1004,3	32,36	32,63949611
1561947000	1-lug-19	1004,3	32,33	32,609237
1561947600	1-lug-19	1004,2	32,27	32,54220968
1561948200	1-lug-19	1004,2	32,67	32,94558383
1561948800	1-lug-19	1004,2	32,46	32,7338124
1561949400	1-lug-19	1004,2	32,46	32,7338124
1561950000	1-lug-19	1004,2	32,21	32,48170356
1561950600	1-lug-19	1004,1	32,13	32,39454917
1561951200	1-lug-19	1004	32,43	32,69048053
1561951800	1-lug-19	1003,9	32,52	32,77464784
1561952400	1-lug-19	1003,8	32,71	32,95954306
1561953000	1-lug-19	1003,9	32,13	32,38159394
1561953600	1-lug-19	1004	32,44	32,70056085

The results obtained were examined and discussed during the next meeting on 29th October 2020 using the same methods of communication. Each group presented their conclusions and method of collection and then, collectively, produced the following graphs using the three best results.
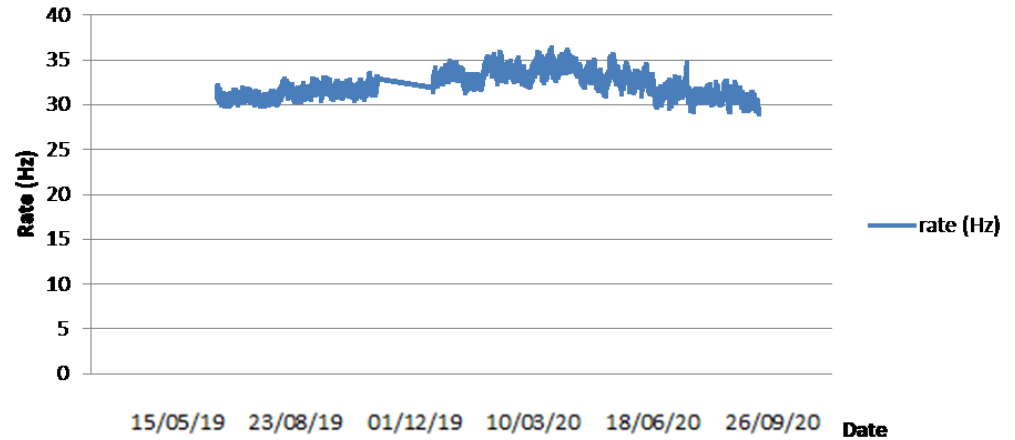
FIRST PART ANALYSIS

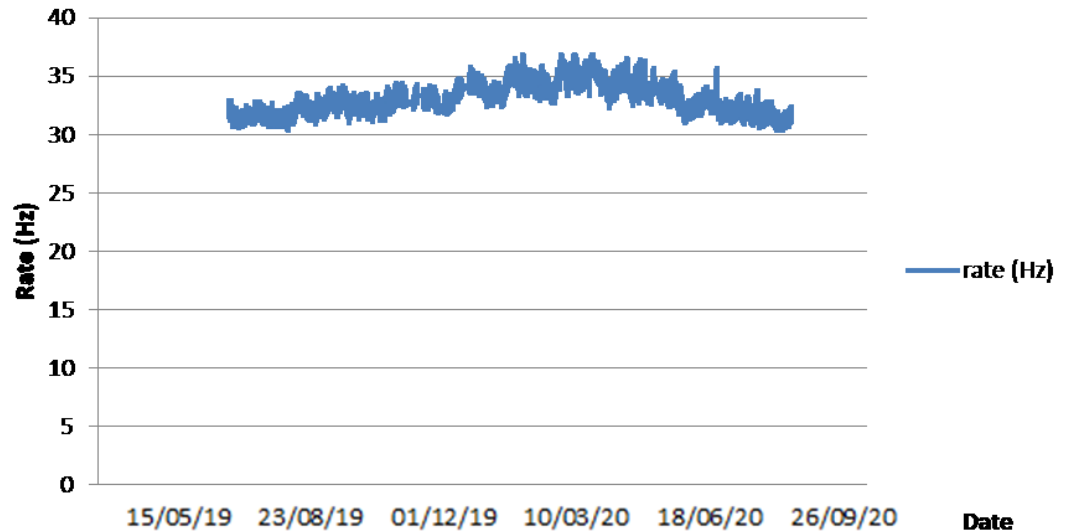## The analysis of the effects are shown in the following graphs

Graph 1 Trend of rate relative to POLA-01 (01/07/2019 to 30/06/2020)
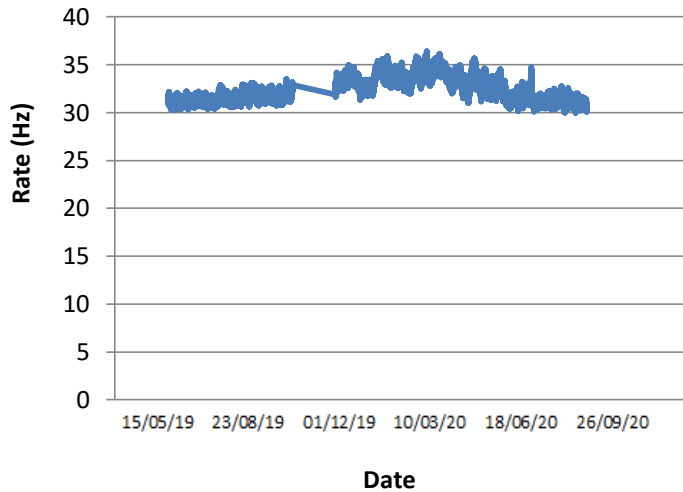
Graph 2 Trend of rate relative to POLA-03 (01/07/2019 to 30/06/2020)

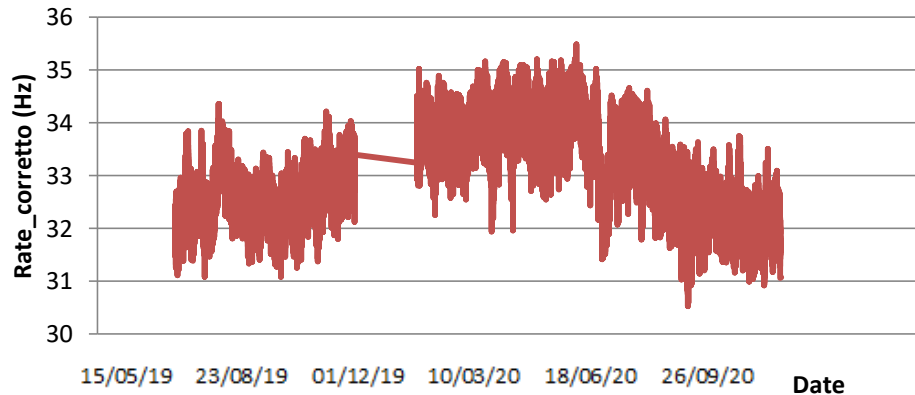**Graph 3 Trend of rate relative to POLA-04 (01/07/2019 to 30/06/2020)**

FIRST RESULTS

- From the analysis of Graphs 1, 2 & 3 it is evident a flow with maximums and minimums in different periods. This could indicate a seasonal variation, but at the moment, it is not correct to draw conclusions on physics, as the rate values are still affected by the barometric effect.

- From the individual graphs it evident to see the maximum and minimum values that have been talked about previously, and these values have been reported by each of the three telescopes in the months of February (max) and June 2020 (min).

- The variations in flux observed between the maximum and minimum values, range from 36.58 Hz (max value) and 29.00 Hz (min). Each telescope shows a percentage valuation of flux of the muons equal to 21.4 (POLA01), 25.9 (POLA03) and 21.5 (POLA04). These percentages have been calculated using the following formula : ((max-min/min)100)%. These variations verify that there is a seasonal trend.
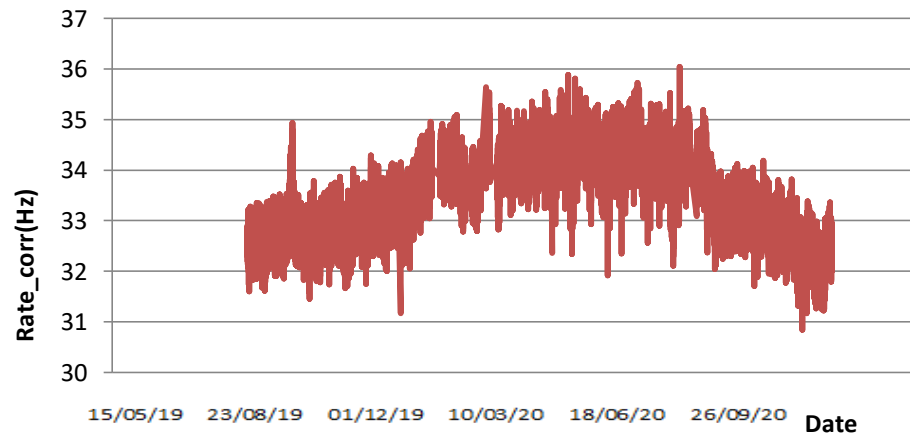
SECOND PART ANALYSIS

Graph 4   Trend of rate corrected by the barometric effect relative to POLA-01
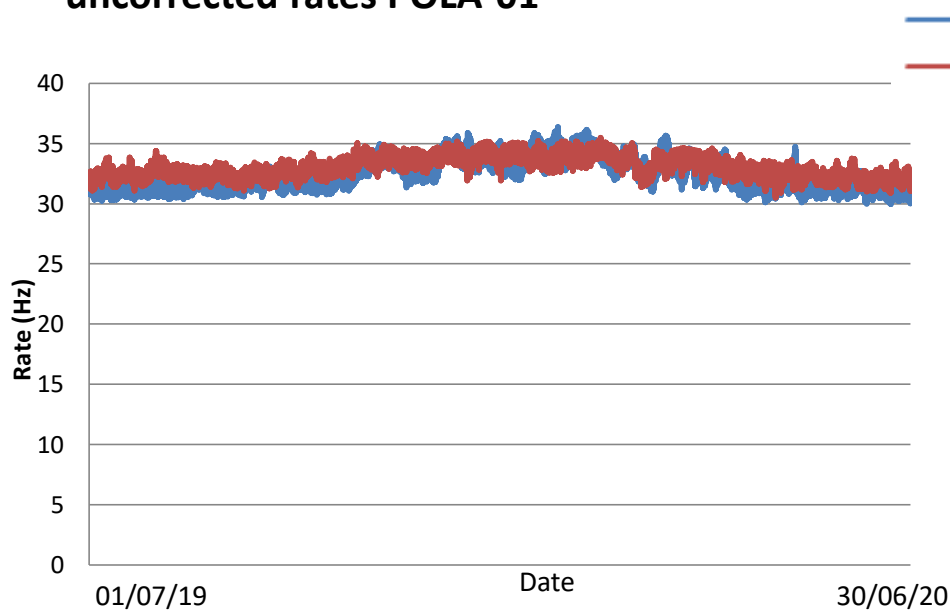
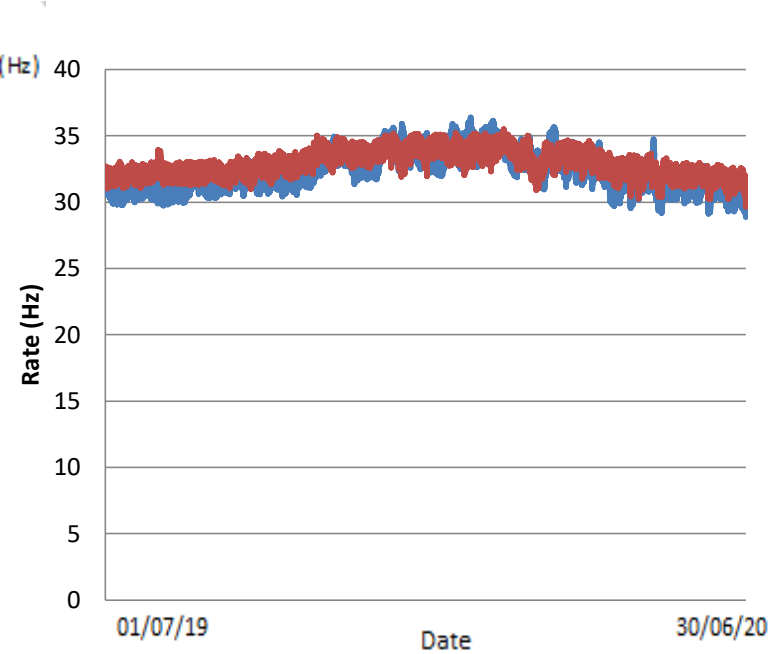**Graph 5   Trend of rate corrected by the barometric effect relative to POLA-03**
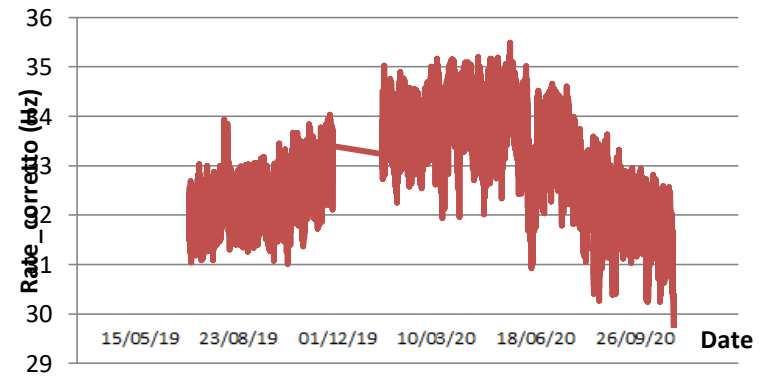
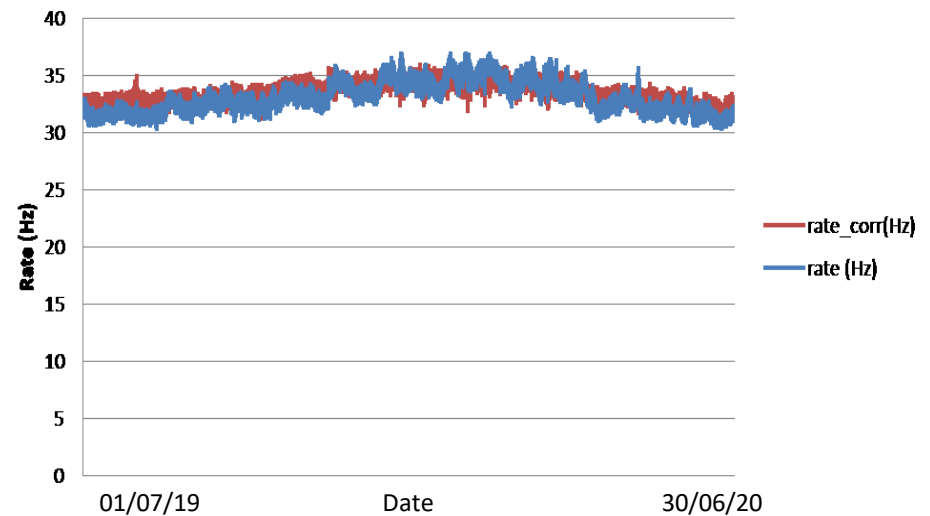**Graph 6   Trend of rate corrected by the barometric effect relative to POLA-04**

Graph 7   Comparison of corrected and uncorrected rates POLA-01

Graph 8   Comparison of corrected and uncorrected rates POLA-03
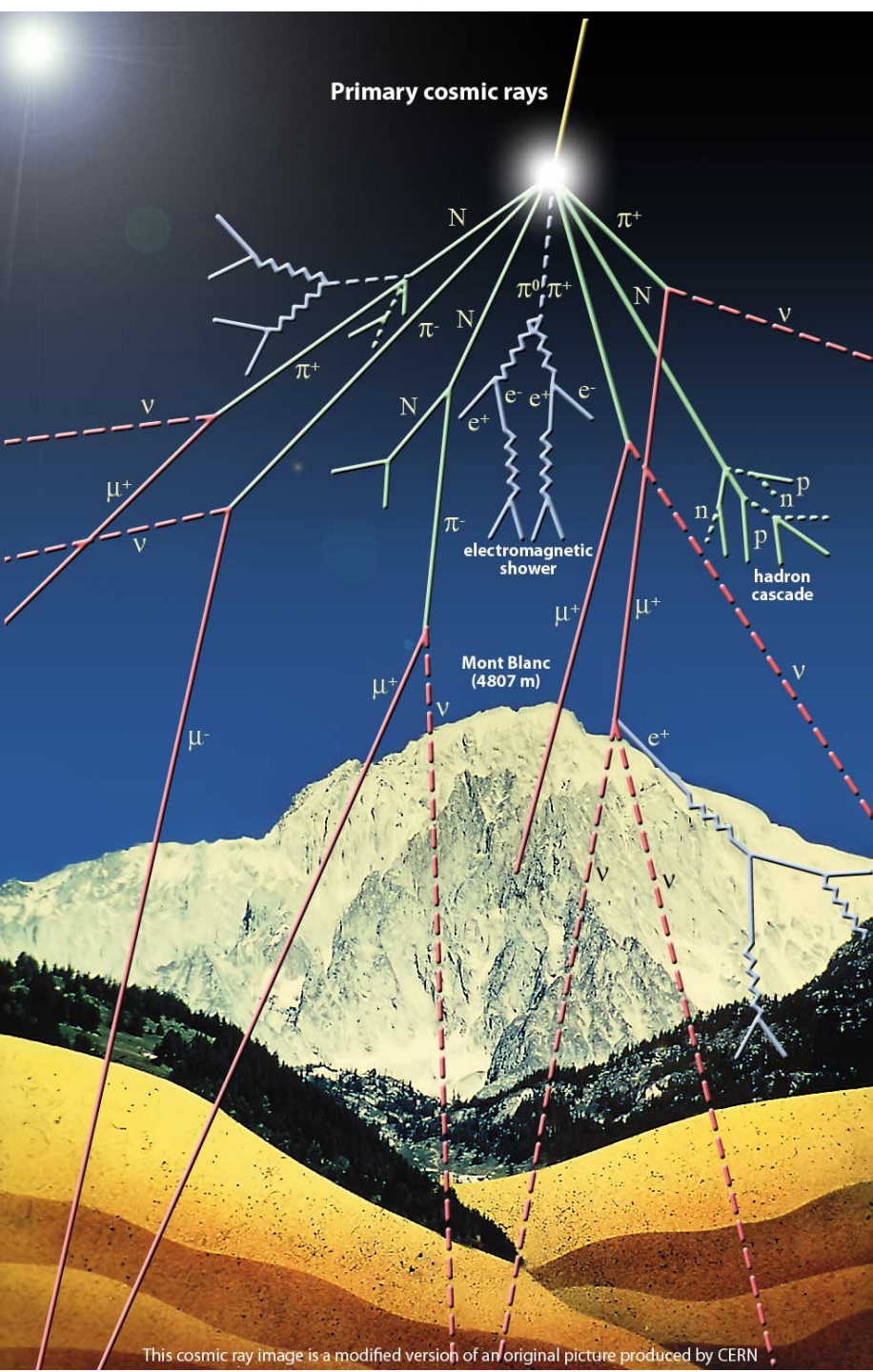
Graph 9   Comparison of corrected and uncorrected rates POLA-04

SECOND RESULTS

The corrected data of rates from the barometric effect is distributed by dates and are shown in Graphs 4, 5 & 6. Graphs 7, 8 & 9 were then formulated in order to provide a better comparison between corrected and uncorrected data for each telescope. It is important to consider the pressure in analysing the rate values because a higher pressure corresponds with a higher density of particles in the atmosphere and therefore, this infers a higher probability that the muons will be reabsorbed at a decreasing rate.

- The observations of graphs of the corrected values shows that there is evidence of seasonal trends in winter – summer, with the maximum in winter and minimum in summer, as referred to in the previous three graphs.

- For all three telescopes the the maximum and minimum values, corrected and uncorrected, are very close. They are also close in terms of dates taken, both for maximum and minimum values, except for the max value of POLA-04 , which was taken one month later than the others

- The difference between each of the two trends shown in graphs 7, 8 & 9 are not particularly noticeable. In terms of the percentages, calculated between the maximum and minimum rates , the values are 30.6 (POLA01), 35.3 (POLA03) and 16.09 (POLA04). This confirms that there is a seasonal trend in the flux of muons. However, there is a decrease in the percentage of the variation in POLA04 . POLA 04 sees less flow variation than the other POLA and the reason should be investigated. it would be necessary to know the efficiency of the detector, its position, in which structure it is located, the materials surrounding it and above it, etc.

Primary cosmic rays

N   π⁺
π⁰ π⁺
π⁻ N   N   ν
π⁺
N
e⁻ e⁺ e⁻
e⁺
n p
ν   n p
π⁻   p
electromagnetic
shower
hadron
cascade
μ⁺   μ⁺
Mont Blanc
(4807 m)   ν
μ⁺
ν   e⁺
μ⁻   ν ν

This cosmic ray image is a modified version of an original picture produced by CERN

CONCLUSION

The analysis of data confirms that there is a **seasonal trend in the flux of muons,** «winter – summer», with higher values in winter and lower values in summer.

In fact, when the temperature increases and the atmosphere expands , the muons, created from the interaction of primary cosmic rays and atmosphere, will form earlier and decay before they reach the surface of the earth, and vice versa when the temperature drops in winter.

The **barometric corrections**, eliminating the meteorological influences on the flux of particles, has further evidenced a higher value of percentage variations in the flux of muons, about 10% more.

THANKS FOR YOUR ATTENTION