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Study for the correlation between neutrons detected by ENDA and soil humidity

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Introduction:

Electron-Neutron detector (EN-detector) can simultaneously record thermal neutrons and the charged particles in the EAS front. In a previous study demonstrated that during the rainy season, the number of neutrons recorded by the ENDA-16-YBJ is lower than in the dry season. So five soil moisture meters (WKT-SH1920) were installed inside ENDA-16-HZS to explore the effect of humidity on the performance of the EN- detector.

Experimental Setup:

The EN-detectors were assembled and tested in a laboratory at Hebei Normal University, and then they are installed at LHAASO on Haizishan (HZS) Sichuan (4400m a.s.l.)(see Fig.1). The five soil moisture meters were installed at a distance of about 1.4m from one of the detector No. 8 to monitor the humidity in the soil. Their probes are buried in the soil and distributed vertically in a depth from 0.2 m to 2 m under the ground. (see Fig.2)

Result:

Rains mainly occurred in September 2020, and only the humidity of No.1 and No.2 changed significantly during rainfall. Because of some detectors are affected by lightning so that their work was not stable, we select the detector 4, 5, 7, 8, 9, 10, 11 and 14 for analysis. Counting rate of one detector is smoothed in 20 min. On September 4 it did not rain, the counting rate of that day is used as the standard one R_b, The relative difference of detector's counting rate is :

$$\delta = \frac{R_n - R_b}{R_n} \times 100\%$$

δ is the relative difference value of the count rate, R_n is the counting rate of EN-detector. By analyzed the rainy month data (September 2020), the counting rate is negatively correlated to humidity in soil. It's showed in Fig.3 and Fig.4. Meanwhile, the correlation between the number of neutrons in the trigger events and humidity in soil is also studied. The total number of neutrons in the trigger events recorded by the eight EN-detectors per hour are counted in this month. With the increase of humidity in soil, the number of neutrons in the trigger events reduces (shown in the Fig.5).

Conclusion:

The ENDA-16-HZS is operating stably. By analyzing the data in September 2020, it is confirmed that when rainfall occurs, the humidity of soil vary differently in different depth, the count rate of EN-detector get influenced and it also affects the neutrons in the trigger events. We hope to get more data during the rainy season in 2021, to quantify the correlation parameters, which are beneficial for correction of neutrons number detected in EAS events and so to reduce of systematic uncertainties in the final energy spectrum recovering of different primary cosmic ray components.

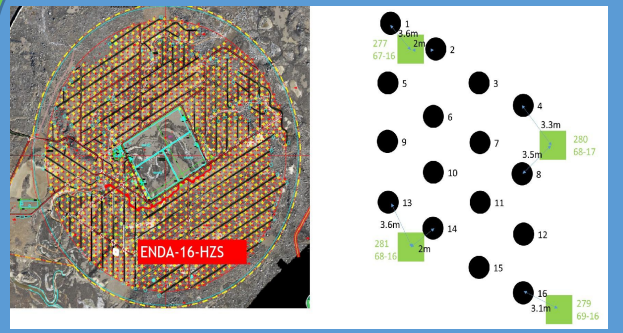

Fig.1: left: The location of ENDA-16-HZS inside LHAASO. right: Configuration of ENDA-16-HZS. Black circles are EN-detectors. Green squares are EDs.

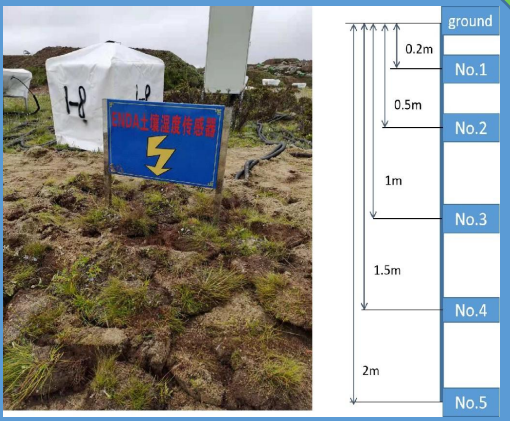

Fig.2: Configuration of soil moisture meters.

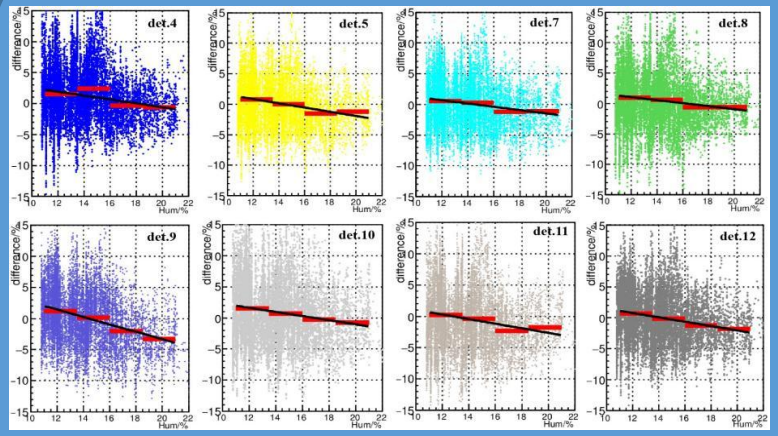

Figure 3: linear fitting of profile of δ vs humidity of No.1 soil moisture meter

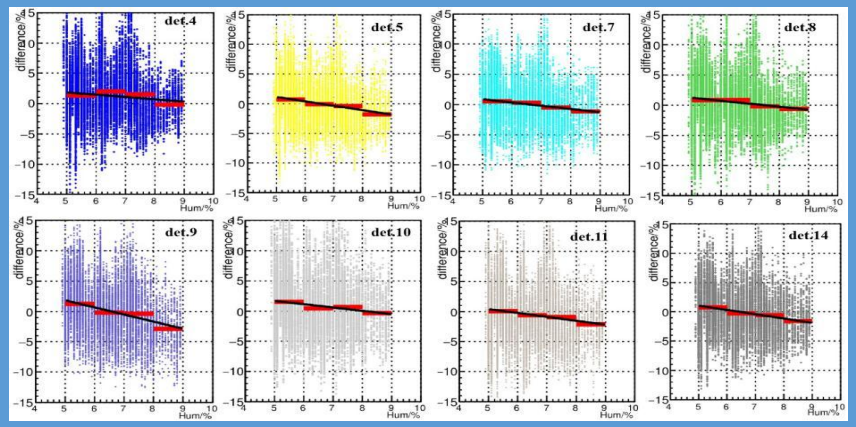

Figure 4: linear fitting of profile of δ vs humidity of No.2 soil moisture meter

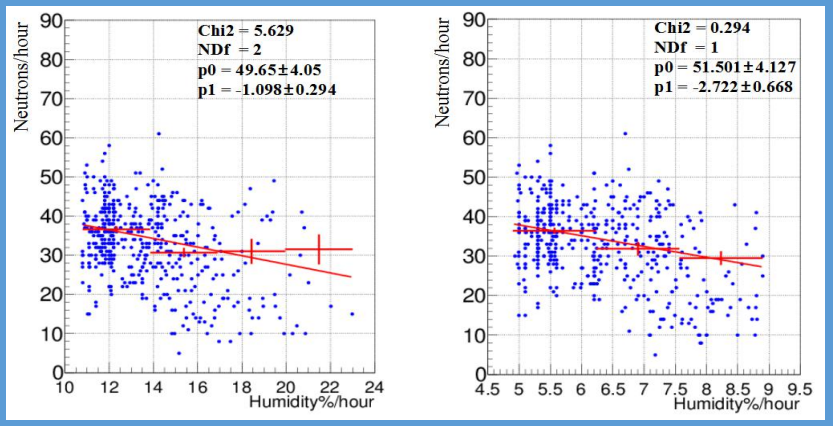

Figure 5: the linear fitting of of scattering plot of neutrons per hour vs humidity in soil