Study of the EN-Detectors Array in Tibet

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Introductions

➢ *Physics motivation*

Hadronic components are "skeleton" of EAS and possess information of primary particles, which can help to solve "knee" problem. EAS hadrons can inspire many thermal neutrons by reacting with materials surround detector.

So through a scintillator sensitive to thermal neutrons, *Electron-Neutron detector* (EN-detector), developed at Institute for Nuclear Research Russian Academy of Science(INR RAS), can record electronic and hadronic component simultaneously in an EAS, and provide new approaches to study "knee" region, as it is demonstrated in the *PRImary Spectrum Measurement Array* (PRISMA) project.

➢ *Experimental Setup*

There are two arrays composed of EN-detectors operating in Tibet. One is located in Yangbajing Cosmic Ray Observatory (4300m a.s.l.), named PRISMA-16, and another at Tibet University (3800m a.s.l.), named P-TU.

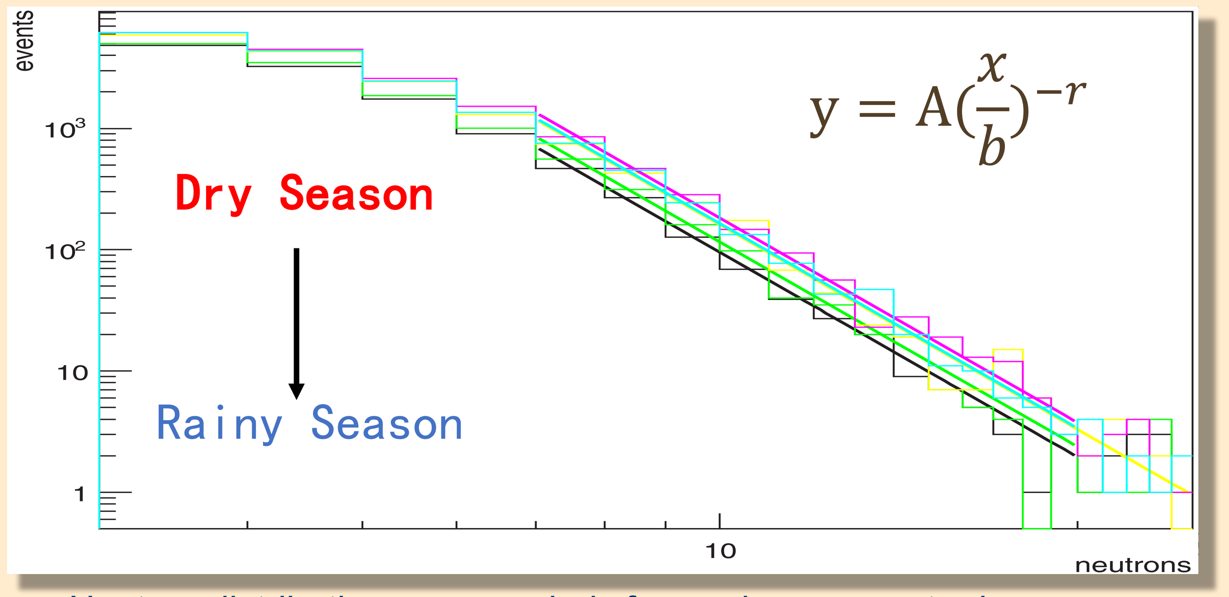
Prisma-16 at Yangbajing Cosmic Ray Observatory

Results

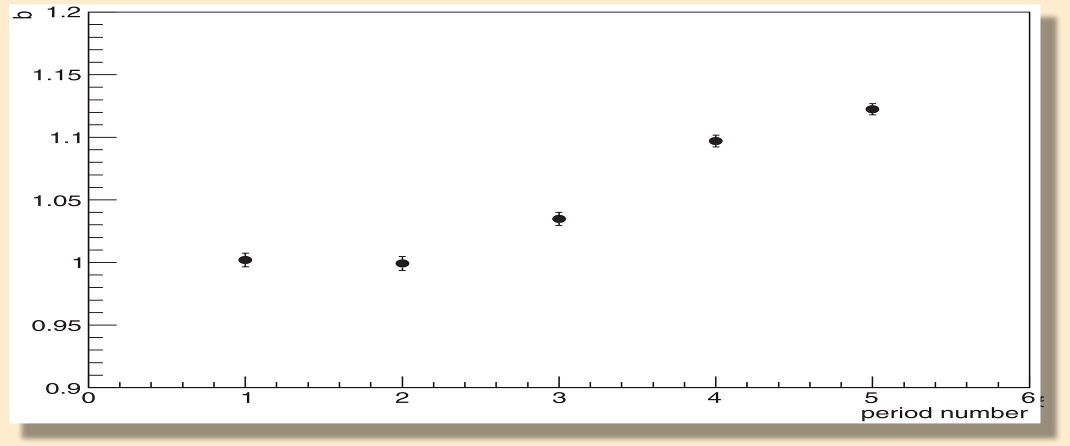
➢ *Neutron generation influenced by moisture*

PRISMA-16 is composed of 16 EN-detectors, and it found that counting rate of thermal neutron and moisture in soil are anti-correlated. That means drier the weather, higher the counting rate.

Upper figure shows comparison of neutron distributions over periods. As demonstrated in the plot, neutrons detected in dry season are always more than rainy season. Using the function depicted in the plot, where parameter A = 3.8×10^7 and *r* = 5.6, *b* represents this the change of mean value of neutrons, we got points in the panel below, indicating the difference between maximum and minimum of *b* can reach to 11%. Although the "seasonal effect" bring 11% difference to yearly counts, it will be averaged for long-term measurement.



Neutron distributions over periods from rainy season to dry season.

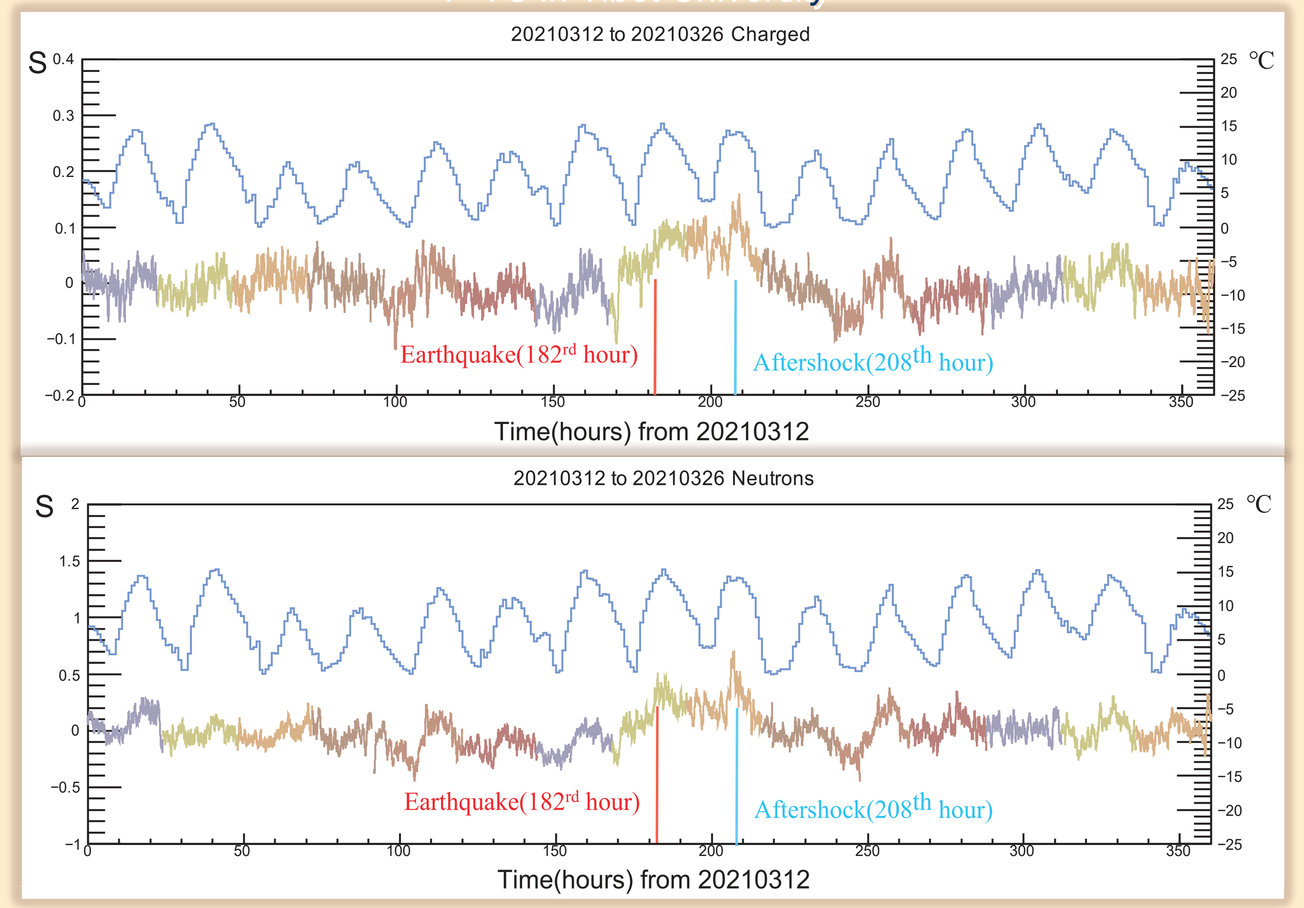


Fitting parameter of b over periods.

➢ *Counting rate increasing during earthquake*

P-TU is composed by 4 EN-detectors running at Tibet University and has recorded an increase when an earthquake happened in Naqu, Tibet, at 14:11, Mar 19, 2021 and another increase at aftershock happened. Results are shown in follow, where $S = \frac{N}{\langle N \rangle} - 1$, and *N* is counting rate. The blue histograms in every frame is variation of hourly averaged temperature in Lhasa. Graph of different color meaning different day. A smooth of 30 minutes time span is employed.

P-TU in Tibet University



Variation of S of neutron (upper) and charged particle (below) during the 7 days before and after Naqu earthquake.

Future Project

➢ *"Sand Cube" to reduce seasonal effect*

Because the change of neutrons could be 11% in long term observation, an idea of "sand cube" is proposed to reduce this seasonal effect. Sand cube, shown in picture, is a cubic tank of 1 m^3 filled with dry sand, on which an EN-detector mounted. This structure can segment detector and wet soil apart, and dry sand provides a ideal environment for neutron generation. Therefore, difference brought by season could be reduced.

Sand Cube under construction

Conclusion

EN-detector can record charged particles and thermal neutron in a same EAS shower. PRISMA-16 and P-TU composed by EN-detectors found that neutron distributions seasonal variation and counts of neutron possibly increase resulted by earthquake.