Research Progress on the Correlation between Cosmic Rays and Earthquake Precursors

Haolong Dong[1], Fengrong Zhu[1], Maoyuan Liu[2], Xinrui Gao[2], Yusen Wang[2]

The Key Laboratory of Cosmic Rays (Xizang University), Ministry of Education, Lhasa 850000, People's Republic of China

1.Background and Motivation

Global strong earthquakes (M ≥ 7) occur frequently and cause devastating damage. Current earthquake early warning (EEW) systems relying on P-wave detection can only provide a warning time ranging from a few to tens of seconds, leaving epicentral regions in a warning blind zone. This underscores the urgent necessity to explore prognostic physical precursor signals. Secondary cosmic ray particles (e.g., muons and neutrons) possess exceptional penetrating power, allowing them to probe deep underground and objectively reflect stress accumulation and rupture evolution within the lithosphere. Several studies have noted indications of anomalous variations in cosmic ray flux prior to seismic events. Consequently, monitoring based on cosmic ray precursor signals could potentially overcome the temporal limitations of traditional observations, providing a novel interdisciplinary approach for strong earthquake early warning.

2. Review of Correlation Studies

Global seismicity correlates significantly with cosmic ray (CR) anomalies. Analyzing Auger and neutron monitor data via dichotomization, Homola et al. demonstrated that CR variations precede M ≥4.0 earthquakes by approximately 15 days , with statistical significance exceeding 6σ . The datasets used are shown in the figure below:

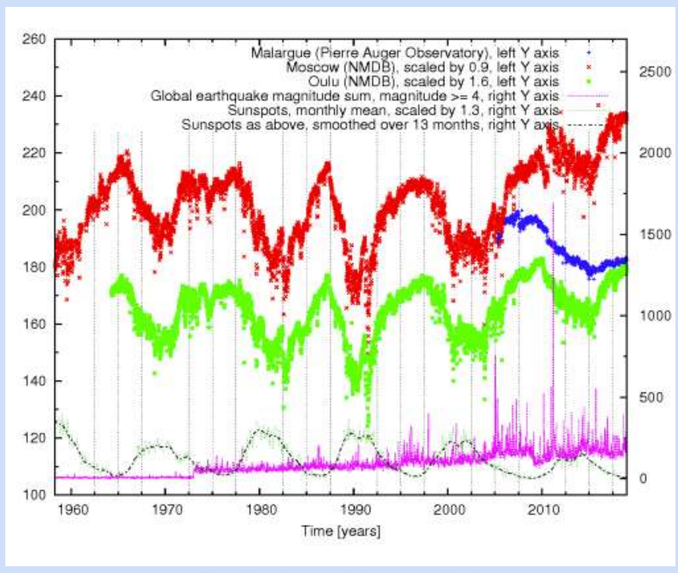


Fig. 1. Plotted curves of the datasets utilized

Homola P, Marchenko V, Napolitano A, et al. Observation of large scale precursor correlations between cosmic rays and earthquakes[J]. Submitted Manuscript, 2021.

Prior to the Wenchuan earthquake, the Yangbajing Neutron-Muon Telescope recorded significant anomalies in cosmic ray data, specifically within the neutron and muon components.

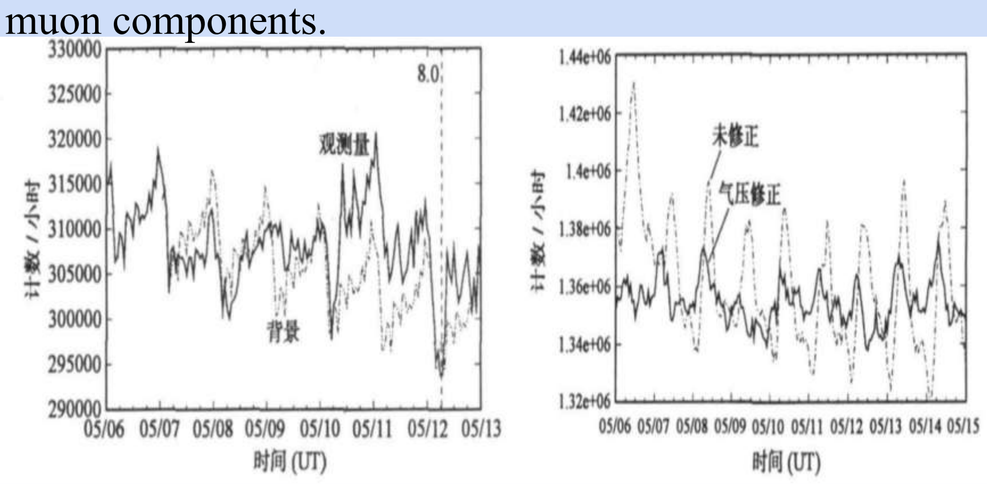


Fig. 2. Hourly count rates of the Yangbajing neutron-muon monitor during the May 12, 2008 Wenchuan earthquake (Ms8.0).

张吉龙，丁鉴海，申旭辉，等。汶川地震前羊八井中子 - μ 子望远镜计数率异常［J］. 电波科学学报，2010，25（2）：227-233.

Specifically, data from the muon monitor revealed that the muon count rate fluctuated by approximately ±15% around May 9, 2008. During the same period, the neutron count rate exhibited a distinct peak suppression phenomenon.

Additionally, the PRISMA-YBJ array in Tibet recorded significant pre-seismic count rate anomalies. As illustrated, the precursor peak reached a significance of 6.5 σ.

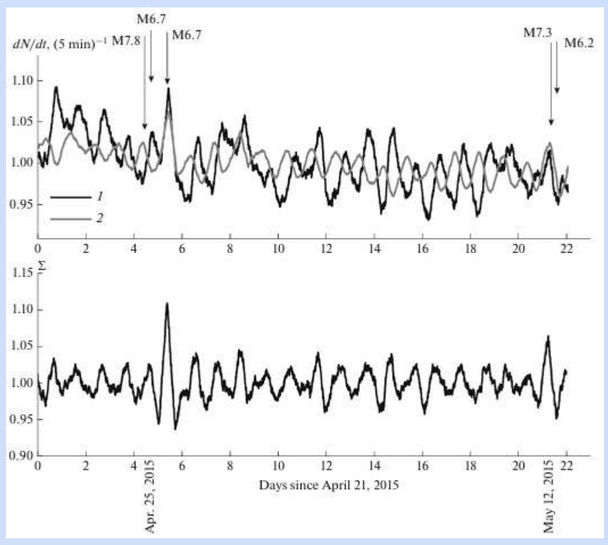
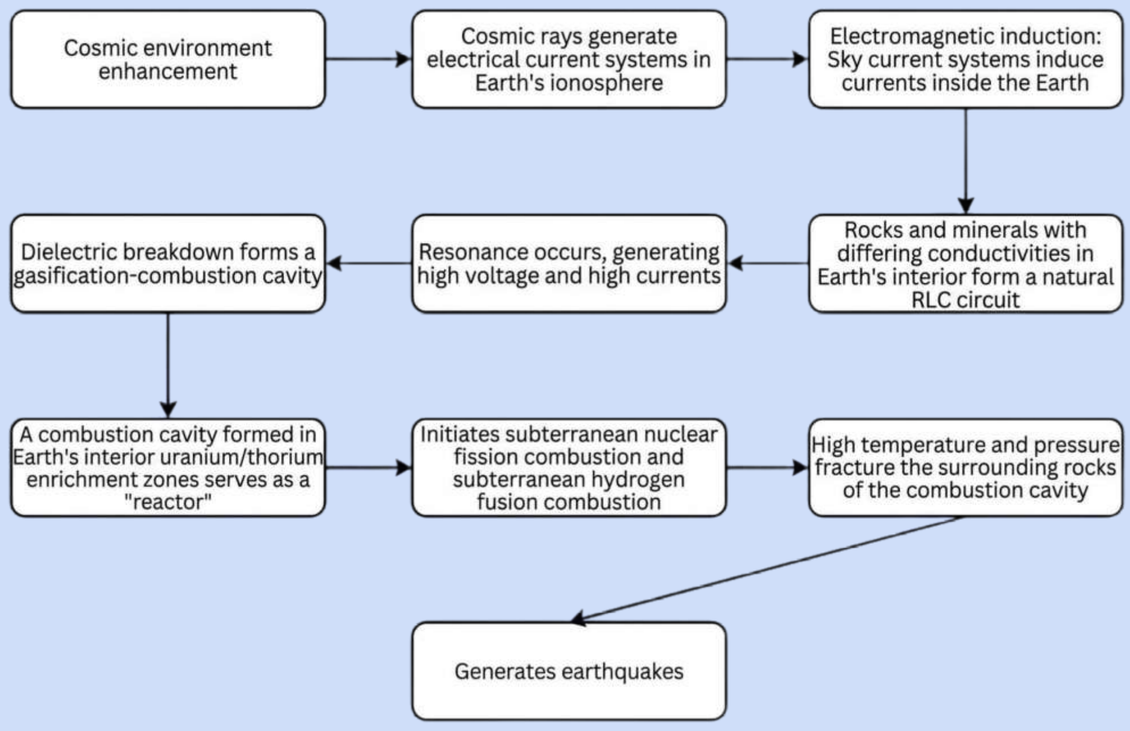


Fig. 3. Pre-earthquake count rate anomalies detected by PRISMA-YBJ

Stenkin Yu V, Alekseenko V V, Cai Z, et al. Response of the PRISMA-YBJ Detectors to Earthquakes[J]. Bulletin of the Russian Academy of Sciences: Physics, 2019, 83(5): 607-610.

3. Underground Nuclear Burning Hypothesis

Research on the correlations between cosmic rays and earthquake provides diverse perspectives for analyzing earthquake mechanisms and developing early warning systems. Within this context, the Subterranean Nuclear Burning Hypothesis proposes the following seismogenic mechanisms



Real-World Observations

- Earth's deep Uranium/Thorium reserves easily provide enough energy to power global earthquakes.
- Subterranean nuclear combustion encompasses both the nuclear fission of Uranium and Thorium as well as hydrogen fusion, for which all requisite conditions are fully satisfied.
- Concentrations of reaction byproducts from the aforementioned two nuclear processes were observed in post-seismic areas.
- Seismic wave data indicates the presence of subterranean high-temperature zones near the Wenchuan epicenter.

Explaining Global Phenomena

- Global earthquake zones naturally align with underground Uranium/Thorium deposits.
- Earthquakes and volcanic eruptions share the same deep-earth trigger.
- Unignited high-temperature zones act as underground "ovens" to create oil and natural gas.

Early Warning Strategy

- Track anomalies in mantle low-velocity layers.Sharp velocity drops serve as early warnings.

虞震东。大地震成因的 “电离层 + 地下核燃烧” 假说［J］. 自然杂志，2004，26（4）：215-218.

4.Conclusion and Outlook

Although many studies have now demonstrated a connection between cosmic ray intensity anomalies and seismicity, this remains insufficient to serve as a reliable earthquake precursor: identifying an anomaly signal only indicates potential seismic risk without pinpointing the epicenter, origin time, and magnitude, falling short of the practical demands for seismic hazard mitigation. Future research must quantify the physical relationship between cosmic ray anomalies and specific parameters such as magnitude, focal depth, and the seismogenic period, based on existing theoretical models. Ultimately, the goal is to integrate these precursory signatures with conventional warning frameworks to develop more accurate Earthquake Early Warning Systems.