Title : A Next-Generation IoT-Enabled Cosmic Ray Detector Based on Arduino Nano ESP32 for Distributed Measurements and Education.

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ABSTRACT

Cosmic ray detection traditionally requires large and costly instrumentation, limiting accessibility for distributed measurements and educational use. While the original MIT CosmicWatch v2 enabled low-cost detection on a miniature scale, its legacy hardware and software impose significant performance constraints. This work presents an upgraded detector based on the Arduino Nano ESP32, providing substantially enhanced computational capability and system integration. The new design incorporates a BME280 environmental sensor and a Neo-M8N GPS module for real-time monitoring of atmospheric conditions and precise positioning. The firmware was completely redesigned using modern libraries and optimized to exploit the ESP32 dual-core architecture, enabling high-rate signal acquisition of up to 1 million samples per second through direct memory access (DMA). Integrated Wi-Fi connectivity further transforms the detector into an Internet of Things (IoT) node capable of transmitting pulse signals, environmental measurements, and geolocation data to a custom web server for real-time remote logging and analysis. System performance was evaluated through a field deployment in collaboration with Mahidol Wittayanusorn School using a high-altitude weather balloon. The results demonstrate clear correlations between cosmic ray count rates and altitude, with additional signal characterization obtained from ADC–pulse width distributions and spectral histograms. These results confirm the detector's reliability and highlight its potential for scalable cosmic ray monitoring networks, distributed scientific research, and educational outreach.

Keywords: Cosmic ray detection, Scintillation detector, Arduino Nano ESP32, Internet of Things (IoT), High-altitude balloon, Direct Memory Access (DMA), Real-time monitoring, Atmospheric sensors, Distributed sensor networks.

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