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Beyond Cosmic Rays: The Evolution of LAGO into a Multidisciplinary Scientific Observatory

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We present the evolution of the Latin American Giant Observatory (LAGO) from an initiative that emerged from the Pierre Auger Observatory to a multidisciplinary research and innovation ecosystem. Initially conceived as a geographically distributed network of water Cherenkov detectors (WCDs) at high-altitude sites to study high-energy gamma-ray bursts, LAGO has progressively expanded its scientific scope, technological capabilities, and societal impact. Today, the collaboration integrates astroparticle physics, space weather, atmospheric radiation, and environmental monitoring within a framework of standardised instrumentation, advanced simulations, and FAIR-compliant data workflows.

Central to this evolution is transforming the WCD into a modular scientific appliance, supported by the ARTI simulation framework, which enables site-specific, time-dependent modelling of cosmic-ray fluxes and detector responses. This approach extends LAGO's capabilities beyond its original scientific objectives to applications such as space weather monitoring, particularly in regions influenced by the South Atlantic Magnetic Anomaly; volcanic muography; cosmic-ray neutron sensing for soil moisture monitoring and precision agriculture; and environmental background radiation studies.

Complementing these developments, LAGO is building a distributed digital infrastructure that integrates edge computing at detector sites with regional and international computing resources, facilitating open science, reproducibility, and collaborative data analysis. Through sustained education, capacity building, and international cooperation, LAGO has strengthened scientific communities across Latin America and Spain while fostering new applications that connect fundamental research with regional challenges and societal needs.

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