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Editorial

Special Issue on Development and Application of Particle Detectors

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Particle detection has been increasingly applied over a wide range of disciplines, including high-energy physics, astroparticles, space science and astronomy, biological sciences, medical imaging, remote sensing, environmental monitoring, cultural heritage, and homeland security. Various types of detectors are being developed to cover this ample range of applications, exploiting different techniques and approaches.

This Special Issue aimed to collect and present all breakthrough research on these disciplines. A total of 11 papers (one research paper and ten review papers) in various fields of astroparticle physics, cultural heritage and high-energy physics are presented.

H. Liu and Y. Zhang [1] proposed a method for an online vertex reconstruction algorithm based on an artificial neural network for a micro-pattern gaseous detector. A simulation based on Geant4 was performed to generate the training and testing samples for two cascade neural networks. Compared with a center-of-mass reconstruction, the proposed method shows better precision and a much higher efficiency.

In recent years, Micromegas (MICRO-MEsh GAseous Structure) detectors have received growing interest for applications in industry, biomedicine, and other scientific fields, including geology and archaeology. D. Attié et al. [2] presented implementations of Micromegas in these different fields, showing the high versatility and performance of the Micromegas detector concept.

Low-temperature detectors have been used in recent decades for applications ranging from neutrino mass measurements to metrology to measurements for safeguards and medical nuclides. While low-temperature detectors have extremely high-intrinsic-energy resolutions, the energy resolution achieved in practice is strongly dependent on factors such as the sample preparation method. K. Koehler's [3] review seeks to present the consensus of the literature on what has been learned by looking at the energy resolution as a function of various choices of detector, absorber, and sample preparation methods.

L. Gottardi and K. Nagayashi [4] reported on the technology of X-ray microcalorimeters based on superconducting transition-edge sensors (TESs) for applications in astrophysics and particle physics. They showed the advances in our understanding of the physics of the detector and described the recent breakthroughs in the TES design that are opening up the way towards the fabrication and the read-out of very large arrays of pixels with unprecedented energy resolutions.

Lately, Microwave Kinetic Inductance Detectors (MKIDs) have emerged as one of the most promising low-temperature detector technologies. Their unrivaled scalability makes them very attractive for many modern applications and scientific instruments. In their paper, G. Ulbricht et al. [5] give an overview of how and where MKIDs are currently being used or are suggested to be used in the future.

M. Beretta and L. Pagnanini [6] review the recent developments in macrocalorimeters, starting from the state of the art and outlining the path toward next-generation experiments, paying particular attention to the evolution of the cryogenic technique that led to the realization of the CUORE experiment. They also showed how parallel studies pointed out that scintillating cryogenic detectors represent a suitable upgrade for the CUORE design, directed towards higher sensitivities.

Detectors are also a key feature of the contemporary scientific approach to cultural heritage (CH), both for diagnostics and conservation. L. Giuntini et al. [7] reported examples of the development and application of new instrumentation to the study of CH. Examples of optimized traditional detection setups for spectrometric techniques are X-ray, gamma-ray, visible-light and particle spectrometers tailored for CH applications. Highly innovative detection setups are ARDESIA, the MAXRS detection setup at the Riken-RAL muon beamline and the imaging facilities at the LENA Laboratory. Paths for next-generation instruments have been also suggested.

F. Arneodo et al. [8] discussed and analyzed the main features of a CubeSat mission targeting intense and short bursts of gamma rays. The CubeSats represent a unique opportunity to access space quickly and in a cost-effective way. CubeSats are standard and miniaturized satellites consisting of multiple identical units, with dimensions of about $10 \times 10 \times 10$ cm^3, and very limited power consumption. To date, several hundreds of CubeSats have been launched targeting scientific, educational, technological, and commercial needs.

K. Majumdar and K. Mavrokoridis [9] review and summarize a number of Liquid Argon Time Projection Chamber (LArTPC) experiments, one of the most widely used scintillators in particle detection, due to their low cost and high-resolution three-dimensional particle reconstruction. They briefly describe the specific technologies that are currently employed by single-phase LAr experiments (ICARUS T600, MicroBooNE, SBND, LArIAT, DUNE-SP, ProtoDUNE-SP, ArgonCube and Vertical Drift) and dual-phase LAr experiments (DUNE-DP, WA105, ProtoDUNE-DP and ARIADNE).

N. Charitonidis et al. [10] reported on the design of high-precision neutrino beams, their current limitations, and the latest techniques envisaged to overcome such limits. They put emphasis on monitored neutrino beams and advanced diagnostics to determine the flux and flavor of the neutrinos produced at the source. They also discussed ab initio measurements of the neutrino energy to remove any flux-induced bias in the determination of the cross sections.

Y. Wang and Y. Yu [11] gave a description of the structure and the operating principles of the multigap resistive plate chamber (MRPC) that has been arousing broad interest over the last few decades and has become a new standard technology for time-of-flight systems in high-energy physics experiments. They review applications of the time-of-flight system in several famous experiments. The performances, including time resolution and particle identification, are discussed in detail and some recent advances in next-generation MRPC are also outlined.

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