TRIUMF Advanced Rare Isotope Laboratory (ARIEL)

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Timepix3-Based Optical Time Projection Chamber: Fast 3D Tracking for Low-Energy Nuclear Experiments

An optical Time Projection Chamber (oTPC) is proposed for low-energy nuclear physics experiments at TRIUMF/ARIEL, using a Timepix3-based single-photon camera as readout. When charged particles ionize the detector gas, the resulting electron avalanches produce scintillation light captured by an externally mounted camera with an image intensifier —avoiding the complexity of conventional wire-based systems.
The Timepix3 chip offers a 256×256 pixel matrix with 55 µm pitch, simultaneous time-of-arrival and time-over-threshold readout, and 1.6 ns timing resolution. This enables full 3D track reconstruction by combining pixel position with timing data to avoid pile-up, while the energy-sensitive response adds calorimetric capability.
The system demonstrates high granularity, precise timing, and flexible 3D reconstruction in a compact format, validated with alpha-particle sources and cosmic rays. The oTPC + Timepix3 platform is presented as a promising instrument for next-generation low-energy nuclear experiments at ARIEL.

Primary author: CABO LANDEIRA, Cristina (IGFAE - Universidade de Santiago de Compostela)

Co-authors: FERNANDEZ DOMINGUEZ, Beatriz (University of Santiago de Compostela); Dr ALVAREZ-POL, Hector (Universidade de Santiago de Compostela); Dr CAAMANO FRESCO, Manuel (Universidade de Santiago de Compostela); Dr CORTESI, Marco (Facility for Rare Isotope Beams (FRIB)); AYYAD, Yassid (USC-IGFAE)

Presenter: CABO LANDEIRA, Cristina (IGFAE - Universidade de Santiago de Compostela)

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