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GammaTPC: A Next-Generation MeV Gamma-Ray Instrument

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Exploring the mid-range γ -ray regime (0.1-50 MeV) remains a significant challenge in astrophysics due to the lack of sensitive instruments in this energy band. To address this gap, we propose the GammaTPC, a novel MeV γ -ray instrument concept utilizing a liquid argon (LAr) time projection chamber (TPC). This instrument aims to achieve an all-sky survey capability with a large effective area, extensive field of view, and high sensitivity to polarization. The GammaTPC promises pointing and energy resolution comparable to or exceeding current missions, such as AMEGO, by using a novel charge readout architecture (GAMPiX).

The GammaTPC concept leverages the benefits of a TPC, such as fine spatial resolution and effective background reduction, to enhance the detection of Compton and pair production events. Additionally, GammaTPC's ability to measure electron recoil tracks significantly enhances angular resolution and polarization detection. Its large area and the use of inexpensive active material, liquid argon, make it a cost-effective solution for high-sensitivity γ -ray observations.

Preliminary Monte Carlo simulations indicate that GammaTPC will significantly surpass the sensitivity of existing instruments, offering a transformative leap in γ -ray astronomy. This development promises to fill the observational gap in the mid-range γ -ray band and open new windows for studying cosmic phenomena, including relativistic jets, nuclear processes, and potential dark matter signatures, thereby advancing our understanding of the universe.

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