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Gamma-ray observations in the MeV band: Current Status and Future Prospects

Gamma-ray line observations in the MeV band are crucial to understanding cosmic matter production, e.g., 511 keV lines from positron annihilation, nuclear lines originating from nucleosynthesis, and signatures of MeV-scale dark matter. However, the MeV band has remained one of the most challenging energy ranges in astronomy due to high instrumental backgrounds, limited photon statistics, and the complexity of Compton scattering events. Despite significant efforts over the past decades, the achieved sensitivities have been insufficient to address many fundamental questions in this energy range.

In this talk, I will first provide an overview of the current status of MeV gamma-ray observations, reviewing key observational results and challenges. I will then present our recent all-sky analysis of the 511 keV line using 20 years of INTEGRAL/SPI data, which represents the most sensitive survey of Galactic positron annihilation to date, and discuss the implications for understanding positron sources and propagation. Finally, I want to discuss future prospects for MeV gamma-ray observations, including the upcoming COSI mission and the scientific opportunities that next-generation observations will enable.