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Time variability of the Galactic cosmic ray distribution and the associated multi-messenger interstellar emissions

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Cosmic rays (CRs) are trapped within the Milky Way and diffuse through the interstellar medium (ISM) for millions of years. This confinement and propagation process creates a pervasive "sea" of relativistic particles that interact with the diffuse gas, radiation, and magnetic fields in the ISM to produce secondary emissions over a broad energy range from all directions on the sky.

The Fermi Large Area Telescope has measured the diffuse gamma-ray emissions for >100 MeV energies with high statistics, and recent results from H.E.S.S., HAWC, LHAASO, and the Tibet Air-shower Array show also that these diffuse emissions are produced up to PeV energies. The different energy ranges are connected due to the common origin of the CR particles injected by individual sources and propagating through the ISM. However, the properties of the ensemble of CR sources, including their injection spectra and relative proportion of different source classes (e.g., supernova remnants, pulsars), are not well understood.

In this contribution we use the latest v57 release of the GALPROP framework to make fully 3D models for the activity of ensembles of discrete spatial/temporal CR sources in the Milky Way, and make predictions for the diffuse secondary emissions from GeV to PeV energies. We discuss our results within the context of the data collected by space- and ground-based instruments, including possible constraints for the distributions of CRs and other ISM components.

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