

## **Advancing Cosmic-Ray Modeling to Illuminate the Magnetized and Multiphase Galaxy**

Low-frequency radio observations of synchrotron radiation offer a unique vantage point for investigating the intricate relationship between gas and magnetic fields in the formation of structures within the Galaxy, spanning from the diffuse interstellar medium to star-forming regions (Bracco+2020, 2022, 2023).

Achieving this pivotal objective hinges on a comprehensive understanding of cosmic-ray (CR) properties, which dictate the effective energy distribution of relativistic electrons (CRE), primarily responsible for observable synchrotron radiation. Notably, CRE with energies below 10 GeV are crucial for the majority of sky brightness below the GHz range, yet their energy flux ( $J_e$ ) remains elusive due to solar modulation.

We propose deriving observational constraints on the missing energy gap of interstellar CRE through the spectral index of low-frequency radio emission, denoted as  $\beta$ . Presenting a recently accepted paper on a new analytical model (Bracco+ 2024), I will showcase its precision in fitting  $J_e$ , considering  $\beta$  values measured in the literature for diffuse emission in the Milky Way (between 50 MHz to 1 GHz) and a magnetic-field strength consistent with observations below 10  $\mu$ G.

This research marks a significant stride in modeling Galactic diffuse emission, providing essential insights in preparation for the imminent arrival of the Square Kilometer Array.