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Probing cosmic rays in nearby giant molecular clouds with the Fermi Large Area Telescope

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We report the results of our study of the energy spectra and absolute fluxes of cosmic rays (CRs) in the Local Galaxy based on a five-year γ -ray observation with the Fermi Large Area Telescope (LAT) of eight nearby giant molecular clouds (GMCs) belonging to the Gould Belt. The γ -ray signals obtained with high statistical significance allow the determination of γ -ray spectra above 300 MeV with adequate precision for extraction of the energy distributions of CRs in these clouds. Remarkably, both the derived spectral indices and the absolute fluxes of CR protons in the energy interval 10 – 100 GeV agree with the recent direct measurements of local CRs by the PAMELA experiment. This is strong evidence of a quite homogeneous distribution of CRs, at least within several hundred parsecs of the Local Galaxy. Combined with the well established energy-dependent time of escape of CRs from the Galaxy, $\tau(E) \propto E^{-\delta}$ with $\delta \approx 0.5 - 0.6$, the measured spectrum implies a CR spectral index of the (acceleration) source of $\approx E^{-2.3}$. At low energies, the spectra of γ rays appear to vary from one cloud to another. This implies spatial variations of the energy spectra of CRs below 10 GeV, which at such low energies could be explained naturally by both the impact of the propagation effects and the contribution of CR locally accelerated inside the clouds.

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