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Cosmic ray interactions with molecular clouds using GEANT4 simulation

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Galactic cosmic rays (protons and atomic nuclei etc) are produced in plausible sources like supernova explosions, pulsar wind nebula, etc. The kinetic energy of these particles can extend over many orders of electron volts. It is expected that PeV cosmic rays are produced in these Galactic sources. After leaving their point of origin, they travel through the interstellar medium. Dense gas regions like molecular clouds in the interstellar medium provide target hydrogen gas density for the interaction of cosmic rays. This further creates a variety of secondary particles, i.e., gamma-rays, neutrinos, etc. Even though many experimental and theoretical studies have been conducted in the past, we still have a lot to learn about the origin, production, and acceleration processes of the highest-energy GCR particles. In this context, we have used the GEANT4 Monte Carlo simulation toolkit to simulate the production of secondary cosmic ray particles as a result of the primary GCR particle interaction and propagation through these dense molecular clouds. These investigations are useful to identify PeV cosmic ray sources near a molecular cloud in our Galaxy.

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