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Targeted search for point sources of neutrons using data from the Pierre Auger Observatory

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Since the arrival directions of neutral particles point directly to their origin, they can be used to investigate sources of ultra-high-energy cosmic rays (UHECRs). The emission of UHECRs from a source is expected to be accompanied by the production of neutrons in its vicinity in nuclear interactions and via photo-pion production. Free neutrons undergo β-decay and travel a mean distance of $9.2\times(E/\mathrm{EeV})$ kpc. Therefore, neutron fluxes in the EeV range could be detected on Earth from sources of UHECRs in our Galaxy. Using cosmic ray data from the Surface Detector of the Pierre Auger Observatory, the largest cosmic ray experiment facility in the world, we investigate neutron fluxes from Galactic candidate sources. Since we cannot distinguish between air showers initiated by protons and neutrons, a neutron flux could be identified as an excess of cosmic ray events around the direction of the candidate source. We look for excesses by comparing the observed signal with the background contribution. As candidate sources, we select objects of astrophysical interest, such as pulsars, microquasars, and magnetars. We also consider the Galactic center and the Crab Nebula as targets, as well as a subset of the γ-ray emitters detected by LHAASO. We consider cosmic ray events with declinations from -90° up to $+45^\circ$ and energies starting at 0.1 EeV. Although we do not find evidence of a significant excess of events that could indicate a neutron flux from any of the tested targets, we establish the upper limit of the neutron flux in each investigated case.

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