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Line emission search from Dark Matter annihilation in the Galactic Centre with LST-1

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Dark Matter (DM) remains a great mystery in modern physics. Among various candidates, the weakly interacting massive particles (WIMPs) scenario stands out and is under extensive study. The detection of the hypothetical gamma-ray emission from WIMP annihilation could act as a direct probe of electroweak-scale interactions, complementing DM collider searches and other direct DM detection techniques. At very high energies (VHE), WIMP self-annihilation is expected to produce gamma rays together with other Standard Model particles. The Galactic Centre (GC), due to its relative proximity to the Earth and its high expected DM density, is a prime target for monoenergetic line searches. Imaging Atmospheric Cherenkov Telescopes (IACTs) have placed strong constraints on the DM properties at the GC, with the Major Atmospheric Gamma-ray Imaging Cherenkov (MAGIC) providing the most stringent limits from 20 TeV to 100 TeV exploiting Large Zenith Angle (LZA) observations. However, the limited field of view (FoV) of the MAGIC telescopes ($< 3.5^\circ$) prevented a detailed study of the extended region around the GC in which an enhanced DM density is expected.
The first Large-Sized Telescope prototype (LST-1) of the Cherenkov Telescope Array Observatory (CTAO), located at the Roque de Los Muchachos Observatory (La Palma, Spain) close to the MAGIC site, has been observing the GC since 2021. With its wide FoV of 4.5°, LST-1 could contribute significantly to the WIMPs search at the GC. The observations are performed at LZA (ZA $> 58^\circ$), which, while required due to the source's low altitude, also optimizes the detection of gamma rays up to 100 TeV and beyond. Here we present the first WIMP line emission search with LST-1. We provide a comprehensive study of the LST-1 instrument response functions for LZA observations and a detailed study of the background rejection in monoscopic observations. We present the most updated results based on simulated data demonstrating improved statistical analyses and new methodologies for spectral line search.

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