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Probing Dark Matter annihilation in the Galactic Centre with TRIDENT

We determine the future sensitivity of the TRIDENT neutrino telescope to dark matter annihilation in the Galactic Centre. By applying the full detector design we show that TRIDENT will probe annihilation rates down to $\langle \sigma v \rangle \approx 5 \times 10^{-27}\,\mathrm{cm}^3\,\mathrm{s}^{-1}$ for a 10 TeV dark matter, which is below the thermal freeze-out benchmark. The analysis is carried out with all-flavour neutrino interactions, where we demonstrate that cascade events, primarily due to $\nu_{e,\tau}$, show greater sensitivity to a dark matter signal compared to the more commonly studied track events. Furthermore, we highlight the impact of a previously overlooked background, Galactic neutrinos produced from interactions between hadronic cosmic rays and interstellar gas. We find dark matter sensitivities are more strongly degraded in the high energy region above $\sim 10\,\mathrm{TeV}$, with a maximal weakening of approximately a factor of ~ 2. This effect remains smaller than the uncertainty associated with the dark matter density profile but can nonetheless mimic a positive annihilation signal. We contextualize these results with a concrete particle model and show that TRIDENT will be able to probe the most interesting untested parts of parameter space.

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