

DM-like anomaly in neutron multiplicity spectra

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A new experiment collects data, since November 2019, at a depth of 210 m.w.e. in the Callio Lab [1] in the Pyhasalmi mine [2] in Finland. The setup, called NEMESIS (New EMma Experiment Searching for Indirect Signals), incorporates infrastructure from the EMMA experiment [3] with neutron and large-area plastic scintillator detectors of the MAZE system [4]. The experiment's primary aim is to combine muon tracking with position-sensitive neutron detection to measure precision yields, multiplicities, and lateral distributions of high-multiplicity neutron events induced by cosmic muons in various materials. The data are relevant for background evaluation of the deep-underground searches for Dark Matter (DM), neutrino-less double beta decay, etc.

Preliminary analysis revealed anomalies in muon-suppressed neutron multiplicity spectra collected during a 349-day run (live time) with a 565 kg Pb target. The spectra, well described by a power-law fit, show three peaks at high multiplicities. Although still at a low statistical significance, these small excesses match the outcome of an earlier measurement [5]. The nature of the anomalies remains unclear, but, in principle, they may be a signature of self-annihilation of a WIMP with a mass close to 10 GeV/c² [6]. With that assumption, the expected cross-section would be around 10⁻⁴² cm² for Spin Dependant and 10⁻⁴⁶ cm² for Spin Independent interactions. We propose verifying this hypothesis with an upgraded NEMESIS experiment, able to collect an order of magnitude more data than this measurement. Based on the statistical uncertainty, analysis of the event rate indicates that cross-section limits for DM mass range of approximately 3-40 GeV/c² can be investigated with such a setup.

1. Callio, <https://callio.info>
2. W.H. Trzaska et al., (2018), <https://arxiv.org/abs/1810.00909>
3. P. Kuusiniemi et al., AP 102(2018)67 <https://www.sciencedirect.com/science/article/abs/pii/S092765051730333X>
M. Kasztelan et al., (2006) Proc. the 20th ECRS, Lisbon <https://www.lip.pt/events/2006/ecrs/proc/ecrs06-s0-92.pdf>
4. T. Ward, private communication and AIP Conference Proceedings 842, 1103 (2006); <https://doi.org/10.1063/1.2220467>
5. T.E. Ward et al., APS April Meeting 2019, <https://meetings.aps.org/Meeting/APR19/Session/G17.1>

Reference to paper (DOI or arXiv)

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Primary author(s) : TRZASKA, Wladyslaw Henryk (University of Jyvaskyla)

Presenter(s) : TRZASKA, Wladyslaw Henryk (University of Jyvaskyla)

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