EPJ Web of Conferences **280**, 09002 (2023) https://doi.org/10.1051/epjconf/202328009002
RICAP-22

Sensitivity of KM3NeT/ARCA to a flux of nuclearites

Alice Păun[1,2,*], *Gabriela* Păvălaş[1], and *Vlad* Popa[1] *on behalf of the KM3NeT Collaboration*

[1]Institute of Space Science, RO-077125 Bucharest, Măgurele, Romania
[2]University of Bucharest – Faculty of Physics, RO-077125, Măgurele, Romania

Abstract. Over the past decades, theories have predicted the existence of heavy compact objects containing an extremely dense form of exotic matter named Strange Quark Matter (SQM). This type of hypothetical matter is composed of nearly equal quantities of up, down and strange quarks and is supposed to be the ground state of Quantum Chromodynamics. Nuclearites are the massive component of SQM particles. Some studies show that nuclearites heavier than 10^{13} GeV with velocities of approximately 250 km/s could reach the Earth and could be observed by neutrino telescopes. In this paper, Monte Carlo simulations are used in order to evaluate the preliminary results on the sensitivity of KM3NeT/ARCA to a flux of down-going nuclearites.

1 Introduction

Nuclearites, or Strange Quark Matter (SQM) aggregates, are hypothetical compact and massive particles introduced in 1984 [1, 2]. They are composed of three quark flavours (up, down and strange) [2] and their structure is similar to that of an atom [2]. The detection of SQM aggregates can be done through the blackbody radiation emitted in the visible spectrum along its path, that occurs at the elastic collision between nuclearites and atoms of the medium [2]. Due to this characteristic, nuclearites could be detected by neutrino telescopes. KM3NeT is a network of deep-sea neutrino telescopes located in the Mediterranean Sea, dedicated to the search for high-energy cosmic neutrinos and the study of neutrino properties. The KM3NeT detectors are currently under construction and they are already taking data with the first installed lines.

2 Analysis and results

For this study, an adapted Monte Carlo (MC) simulation code conceived for ANTARES detector was used. The code was modified to correspond to the new geometries, Digital Optical Modules (DOM) and PMT characteristics [3]. The analysis uses MC simulated nuclearite events for masses in the range $3 \cdot 10^{13} - 10^{17}$ GeV/c^2 for the full ARCA configuration. Several distributions were done, relevant for the expected nuclearite signal at the KM3NeT/ARCA depth and the corresponding test cuts were applied (Figure 1 - A, B, C), regarding the three discrimination variables: the triggered hits (at least two hits in a time interval on the same DOM), the snapshot hits (all hits in a time interval larger than the triggered event) and the snapshot duration (the time interval between the last and the first hit observed, with an extra amount of time added).

*e-mail: alice.paun@spacescience.ro

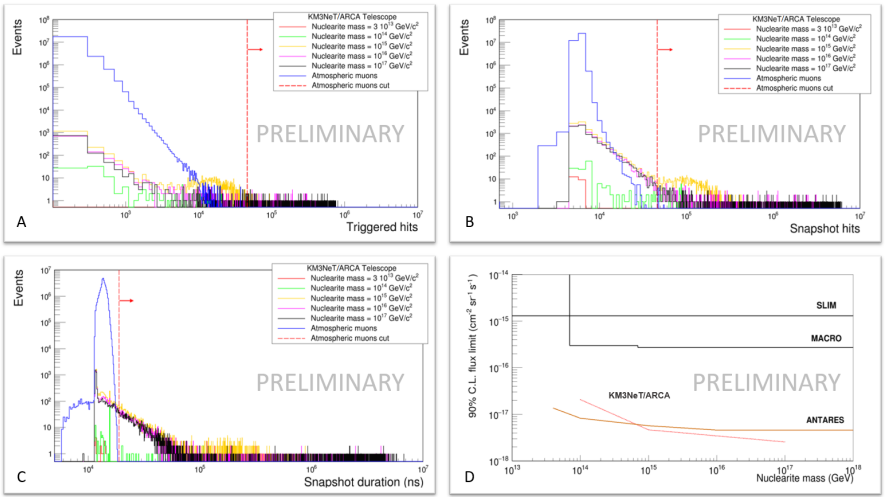

Figure 1. (A) Triggered hits, (B) Snapshot hits and (C) Snapshot duration distributions for nuclearites and atmospheric muons, with optimized cuts through MRF. (D) Preliminary sensitivity results of KM3NeT/ARCA detector to nuclearite signal compared to MACRO [4] and SLIM [5] upper limits and ANTARES [6] sensitivity for 839 days of 2009-2017 data.

The background due to ^{40}K decay is added in the filtering process and the simulated atmospheric muon component is removed by using optimized cuts. The acceptance and sensitivity of KM3NeT/ARCA to a flux of down-going nuclearites were computed, considering the snapshot duration criteria, and the sensitivity was compared to MACRO [4], SLIM [5] and ANTARES (839 days of 2009-2017) [6] results. The ARCA sensitivity at 90% C.L was computed by using the Feldman-Cousins prescription [7], considering nuclearite events with a Poisson distribution (Figure 1 - D).

3 Conclusions

Three variables were evaluated in order to find the best nuclearite selection criteria. The most promising variable was found to be the snapshot duration of the events. The preliminary sensitivity of KM3NeT/ARCA, obtained considering this criteria, was determined for a flux of massive down-going nuclearites at 90% C.L. This result is comparable to and could improve the ANTARES sensitivity obtained for 839 days of 2009-2017 data.

References

[1] E. Witten, Physical Review D **30**, 272-285 (1984)
[2] A. De Rujula, S. L. Glashow, Letters to Nature **312**, 734–737 (1984)
[3] A. Păun et al., JINST **16** (2021)
[4] M. Ambrosio et al., Eur. Phys. J. C **13**, 453–458 (2000)
[5] S. Cecchini, M. Cozzi, D. Di Ferdinando et al., Eur. Phys. J. C **57**, 525–533 (2008)
[6] Bouta et al., Journal of Instrumentation **16** (2021)
[7] G. J. Feldman, R. D. Cousins, Phys. Rev. D **57** (1998)