Search for nuclearites with the ANTARES neutrino telescope

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Introduction

The ANTARES deep sea detector [1] is sensitive to the signal of non-relativistic nuclearites. Nuclearites are hypothetical lumps of strange quark matter that may be present in the cosmic radiation. They are supposed to be massive, neutral particles, with typical velocities of \( \beta \sim 10^{-3} \). They interact with the medium through elastic collisions [2]. Nuclearites could be detected with the ANTARES detector by means of the black-body radiation emitted by their overheated path in water. A dedicated analysis will be presented, as well as the ANTARES sensitivity for a flux of downgoing nuclearites, using a sample of 159 days of data collected in 2009.

Signal and background

Downgoing nuclearites were simulated in the mass range \( 10^{14} - 10^{17} \) GeV. As a characteristic of nuclearite events, after the trigger processing, most of them result in a series of connected snapshots of variable durations, ranging from muon-like snapshots (\( > 4.4 \) ms) to large snapshots of up to few ms, produced by merging. For the physics background, simulated atmospheric muons corresponding to a fraction (\( \sim 8\% \)) of the selected data sample were used. Bioluminescence background is also present in the deep sea environment of ANTARES, causing sporadic peaks in the count rates of up to several MHz during periods of few seconds or less, that mimic at a certain extent the nuclearite signal. Several programs are used to check and identify bioluminescence bursts.

Reconstruction and first level cuts

The reconstruction of nuclearite trajectories uses the charge barycenter distribution as a function of time of the hits. Since the light emitted by nuclearites is isotropic, the charge barycenter gives an estimate of the position of the source at a certain moment. The reconstructed velocities and zenith angles are determined from the linear fits of the charge barycenter distribution projected on each axis as a function of time.

Second level cuts

The number of L0 hits (with charge \( q > 0.3 \) photoelectrons) is used as a discriminant variable. Several snapshots with large number of hits are observed in data distribution. These snapshots belong to several frames in two runs and their investigation indicates a bioluminescence origin. In these particular frames, the number of all snapshots is greater than the one usually seen in the quality runs selected in this analysis, as shown in the right-hand side of Figure 2.

Results and conclusions

As a final step in the candidate event identification, the surviving snapshots are used to look for other snapshots around them in a time interval of \( \sim 1 \) ms, i.e. the time a particle of velocity \( \beta \sim 10^{-3} \) crosses the detector. If found, the sequences of snapshots are reconstructed as events. No events remained for data and MC atmospheric muons.

The preliminary ANTARES sensitivity for a downgoing nuclearite flux is presented in Figure 3. Further improvement of the sensitivity and upper limits can be achieved by extending the search to the next years of ANTARES data.

References

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