Exotic super-massive particles in Neutrino Telescopes

-Synthetic Report-

The goal of this project is to define, develop and implement the search for super-massive, Slowly Moving exotic Particles (SMPs) as GUT magnetic monopoles (MMs), nuclearites and Q-balls with very large volume neutrino telescopes (VLVnT): ANTARES in present and KM3NeT in the future. The research activity is founded by UEFISCDI under Contract 32/2011.

The present experimental lowest flux limits for SMPs are reported by MACRO [1, 2].

Very Large Volume Neutrino Telescopes (VLVnTs) are based on the detection of the Cherenkov light emitted by ionizing relativistic particles, so the search for SMPs should be performed using other interaction mechanisms in mater [3]. Nuclearites may be detected trough the black body radiation emitted along their path [4], GUT magnetic monopoles are supposed to induce proton decay [5,6], and Q-balls would produce experimental signatures similar to those of nuclearites and MMs combined [7].

The search for nuclearites in ANTARES is already in an advanced state, the search for GUT monopolehttps://indico.in2p3.fr/event/7381/overviews is in its initial stage, while the search for Q-balls is to be implemented after the MM procedures will be advised by the ANTARES Collaboration. In all cases there are similar steps to be followed:

- the numerical simulation of the SMP propagation and interaction in mater;
- the detailed Monte Carlo simulation of the SMP passage in the active volume of the neutrino telescope;
- the analysis of the simulated events, to which standard background data are added, using the standard ANTARES data acquisition and processing codes;
- a blind analysis, aiming to determine the optimal analysis cuts, maximizing the sensitivity and minimizing the background contributions;
- the validation of the analysis on a restricted volume (15%) of the real data;
- after the discussion of the preliminary results inside the Collaboration, a formal data unblinding request is presented and then the analysis on the full data may be performed.

Nuclearites.

A preliminary search for down-going nuclearites was completed, using the 2007 – 2008 data [8, 9,10]. As no candidate was found, an upper flux for the nuclearite flux was obtained, represented in Fig. 1 in function of the nuclearite mass. Limits from the MACRO and SLIM experiments are also shown, for comparation. The search for nuclearites is performed assuming that before entering the Earth atmosphere, they travel with a typical galactic velocity, namely 300 km/s. The nuclearite search is restricted to down-going events as at this velocity, a nuclearite should have a mass larger than 10^{22} GeV in order to cross the Earth. Assuming that the mass distribution of nuclearites is similar to that of heavy nuclei in cosmic rays, such events are expected to have a negligible probability.

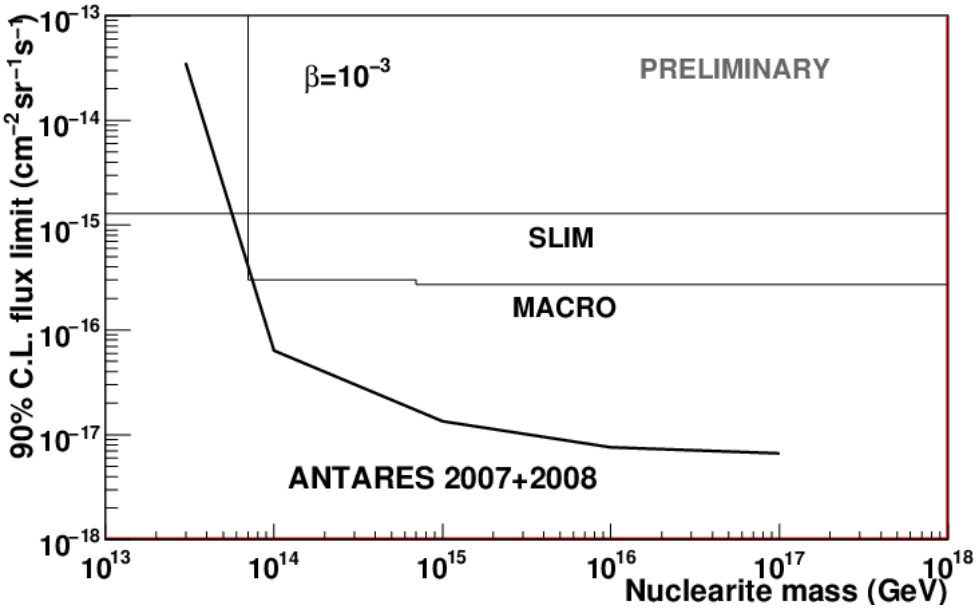

Fig. 1. The preliminary limit for a flux of down-going nuclearites using the 2007 – 2008 ANTARES data.

Presently, the analysis is being updated and new selection criteria, based also on the reconstructed velocity of the collected charge barycentre. As an example, Fig. 2 shows the vertical movement of a simulated nuclearite (in blue) and the reconstructed one (in red) using this technique. The difference is due to the anisotropy of the detectors (the optical axes of the ANTARES photomultipliers are oriented at 45^0 downwards, in order to maximize the efficiency for up-going particles.

The new analysis procedure will be discussed in the Collaboration, and a new unblinding request (for the rest of the data) will be submitted.

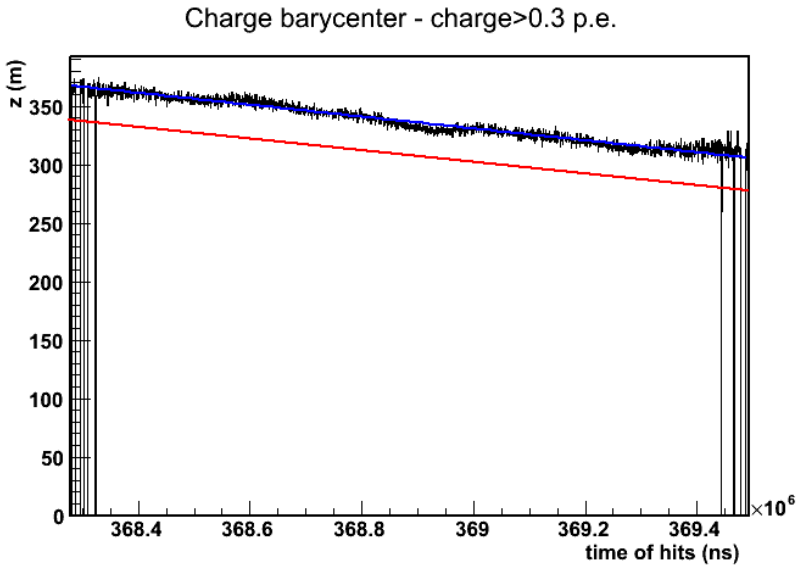

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Fig. 2. Example of trajectory reconstruction based on the collected charge barycentre.

GUT Magnetic Monopoles

GUT magnetic monopoles are expected to have masses larger than 10^{16}-10^{17} GeV. In such conditions, they could cross the Earth, so ANTARES is sensitive to an isotropic flux of poles. The nucleon decay catalysis trough the Rubakov – Callan mechanism is governed by two parameters: an intrinsic cross section and the velocity of the monopole.

Fig. 3 shows the result of a numerical simulation of the passage of a GUT monopole in the active volume of ANTARES.

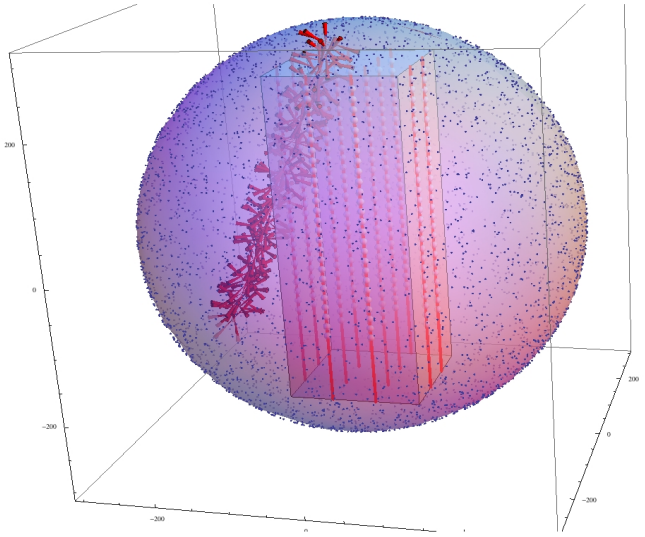

Fig. 3. A simulated monopole event in ANTARES. The charged secondaries are shown.

Presently, a full Monte Carlo simulation of the GUT magnetic monopoles is under development and testing. We intend to present the results in one of the next ANTARES general meetings and to ask for the unblainding of a limited data set, as in the nuclearite search. The results will be published after the Collaboration aproval.

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