SEARCH FOR ALBEDO TRITIUM WITH PAMELA EXPERIMENT

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INTRODUCTION

From modern theories of cosmic ray generation and propagation it is known that the galactic cosmic ray tritium fluxes are of secondary origin only. They appear as a result of the cosmic ray interactions (mostly helium nuclei) with the neutral atoms of the interstellar medium. But as tritium nuclei are unstable (half-life of 12.3 years) and considering that the mean cosmic ray lifetime in the Galaxy is about 6×10^6 years and the atom density of the interstellar medium is of the order of 1000 atoms per cm^{-3} one can conclude that the flux of tritium nuclei is so small that it cannot be registered in cosmic ray experiments such as PAMELA and AMS-02. Observable tritium events in both experiments are the results of interaction between the primary cosmic rays and the material of detectors.

But in case of the albedo fluxes the interactions of high energy cosmic rays with atoms of the upper atmosphere could lead to the existence of measureable albedo fluxes of tritium nuclei and these fluxes can be registered with cosmic-ray experiments in contrary with the GCR component. Some number of experiments had already presented their results for measurements of the tritium nuclei search in low-energy range. This paper is dedicated to further development of method for tritium nuclei identification in energy range from 40 to 400 MeV for experimental data of the PAMELA instrument.

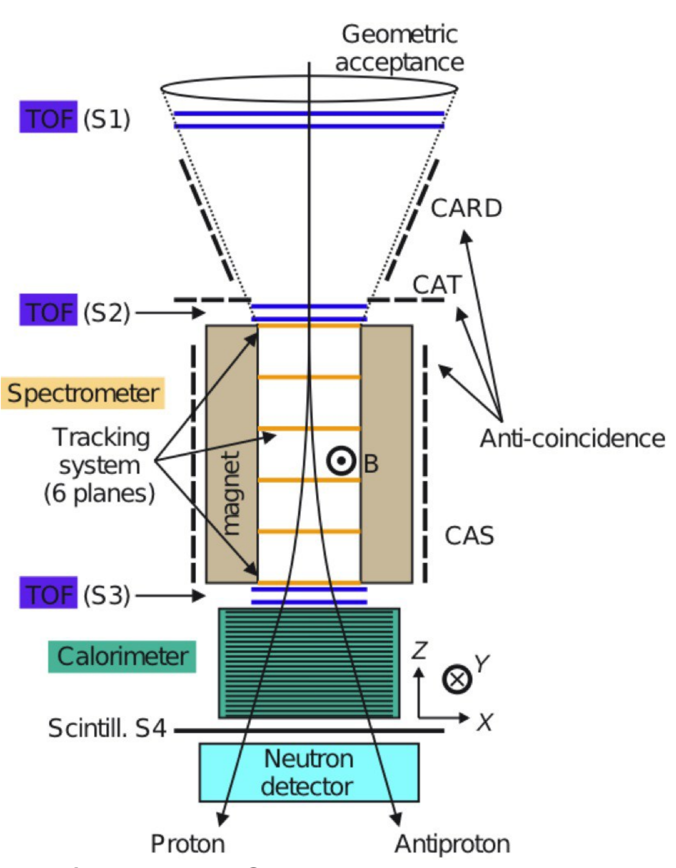

Fig. 1. Scheme of PAMELA instrument.

THE PAMELA EXPERIMENT

The PAMELA experiment [Adriani, O., Barbarino, G.C., Bazilevskaya, G.A., et al., Phys. Rep., 2014, vol. 544, p. 323] is being conducted by a group of scientists from Russia, Italy, Germany, and Sweden. The "heart" of the PAMELA instrument is the magnetic spectrometer (an arrangement of track semiconductor detectors located within the working volume of a permanent magnet). The unit is also fitted with a time-of-flight system that contains three double- layer scintillation detectors, an electromagnetic calorimeter, a scintillation shower detector, and a neutron detector. The working volume of the magnetic spectrometer is surrounded with scintillation counters operating in the anticoincidence (AC) mode. The AC system is used to reject events in which particles enter the spectrometer outside of its aperture.

THE METHOD OF TRITIUM NUCLEI IDENTIFICATION

For collection of the tritium sample from the experimental data the special selection procedure was used. The procedure is based on simultaneous measurements of magnetic rigidity, velocity and multiple values of energy losses in tracker and time-of-flight detectors for registered particle. Data quality selection cuts were used before the start of tritium identification procedure. These cuts allowed to select events where the quality of studied detector responses (such as energy losses, velocity and rigidity measurements are high), so particle selection procedures could be applied.

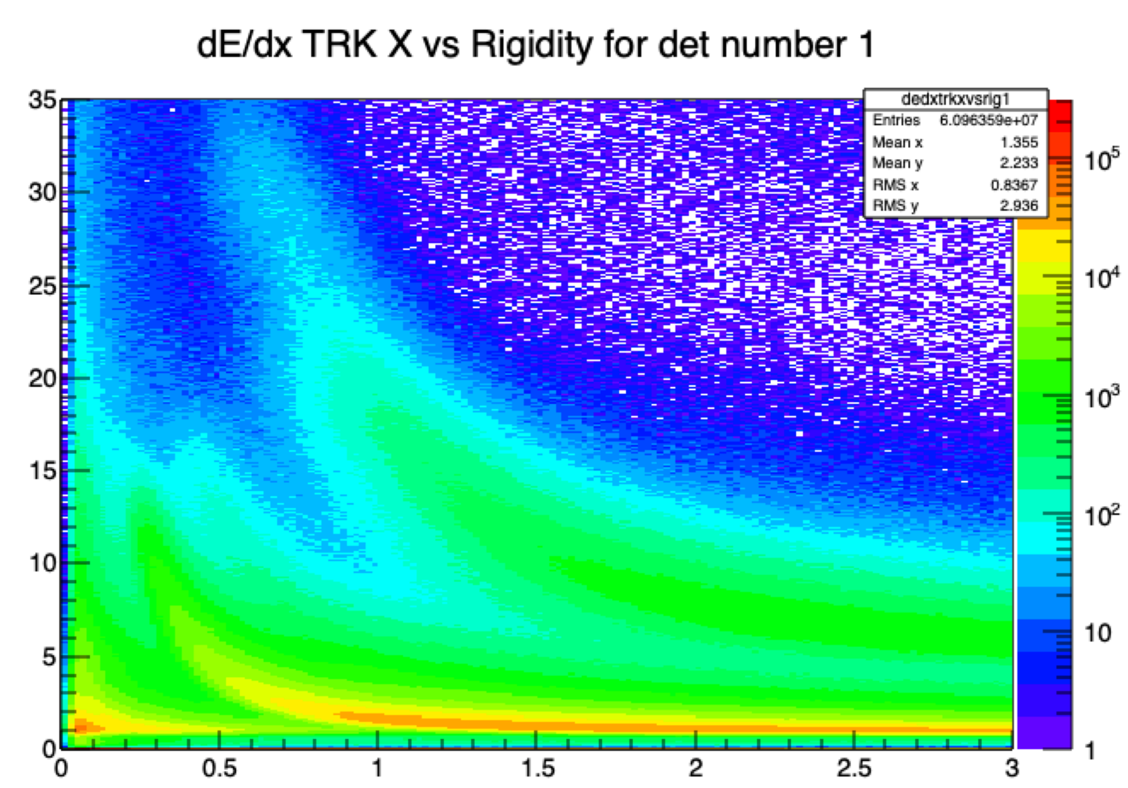

Figure 2. The dependence of energy losses in the second X-view plane of the tracker on reconstructed particle rigidity.

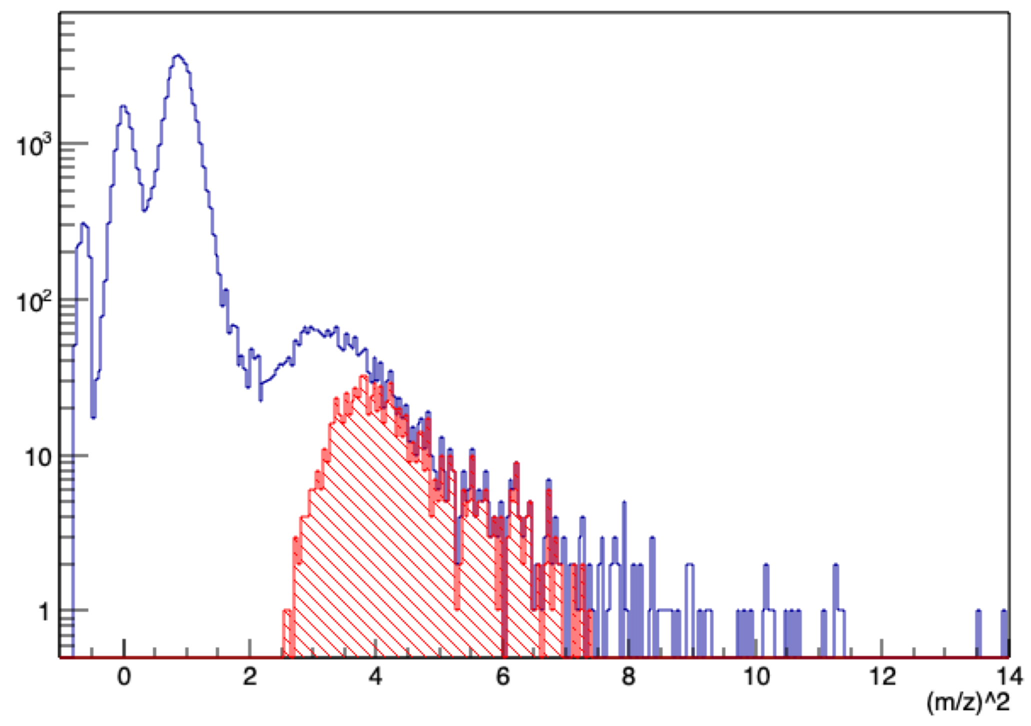

Figure 3. The squared mass-to-charge distribution for albedo particles in energy range for tritium from 50 to 63 MeV/nucleon. No selection applied for blue distribution and energy loss cuts applied to the red one.

The updated method was developed to suppress the background of p, d and He nuclei. It is based on multi parametric analysis of data from several detectors, it allows to identify the sort of particle with high precision and reach high rejection efficiency. This method was described in details in the work discussing a deuteron identification [6].

In addition to previous version of the analysis the independent energy loss measurements were used here for all detectors registering the signals i.e. up to 12 measurements. For each of these obtained values the special selection cuts were developed in diagram energy losses vs. magnetic rigidity. An example of analyzed diagram is shown of Fig. 2, where the dependence of energy loses in the second X-view plane of tracker vs the reconstructed particle rigidity is plotted. The area of tritium events localization is selected from mass-to-charge (where the mass is given is the rest masses of proton) distributions, since tritium is only one nucleus with this ratio about 3. After applying the energy losses vs rigidity cuts the mass-to-charge ratio is plotting again and the number of particles is calculated in result of Gaussian fit of corresponding distribution (Fig. 3).

The efficiency of this method for nuclei selection is one order better that for the method used before for selection of the tritium nuclei wherein a rejection power reaches the value of order 10-4, that in of order of magnitude lower than the rejection power achieved in the old version of method.

Preliminary results of tritium selection show that in the energy range from 40 to 100 MeV/nucleon the enhancement in the spectrum of albedo particles is seen well but in higher energy range there is no any signal. Considering that the predicted tritium flux is small and its spectrum quickly decreases with energy obtained results looks relevant.

Additional checks and calculations should be implemented to reconstruct the spectrum of high-energy tritium registered in the PAMELA experiment. That task will be the essence of further work.