



# Deuteron spectrum measurements under radiation belt with PAMELA

**Koldobskiy S. A., Karelin A. V., Voronov S. A.**  
on behalf of PAMELA collaboration

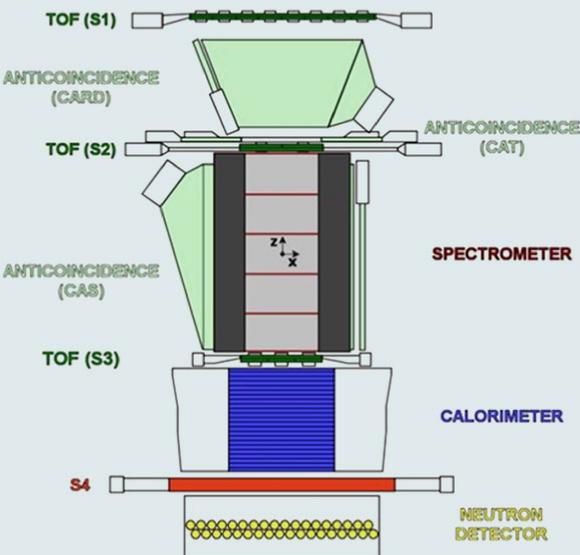
National Research Nuclear University "MEPhI"

mail to: koldobsky.sergey@gmail.com

## 1. INTRODUCTION

Albedo particles are the main product of nuclear interactions between primary cosmic rays (PCRs) and atmospheric nuclei. Measurements of albedo particles are possible under Earth's radiation belt. This measurements are important for better understanding of nature of processes between PCR and atmosphere and for evaluation of radiation near Earth. Till today the only one experiment (Lamanna G., PhD Thesis, Perugia, 2000) gives the spectrum of albedo deuterons. The PAMELA experiment is capable to check this data and expand it to new energies.

PAMELA is a satellite-borne instrument designed for cosmic-ray antimatter studies. The instrument is flying on board the Resurs-DK1 satellite since 2006 June. PAMELA has provided important results on the antiproton (O. Adriani et al., Science, 2011) and positron (O. Adriani et al., Nature, 2009) galactic abundances. The high-resolution detectors allow to identify hydrogen isotopes in energy range from 100 to 700 MeV/nucleon.

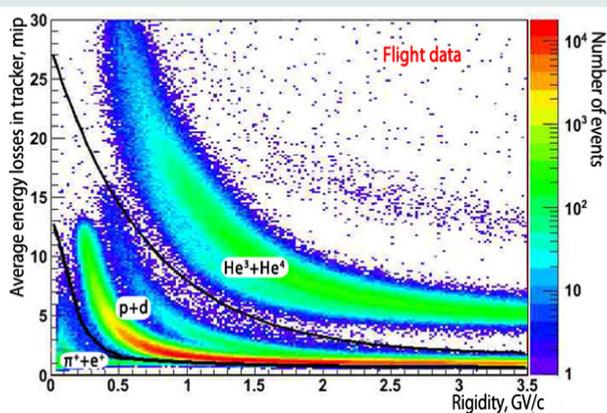


## 2. IDENTIFICATION

For deuteron identification the special method was developed. It was described in detail in (S. A. Voronov et al, Instr.Exp.Tech., 2011). Below the brief description of this method is given.

Responses of different detectors, which depend on the characteristics of detected particles, are used to discriminate deuterons from other particles.

First step of the identification procedure is an distinguishing hydrogen isotopes from another positively charged particles. It was done by applying of some general cuts applied to whole flight data array and by consideration of truncated average energy losses for particles crossing spectrometer (the Figure below).



And the second step was identifying of protons and deuterons by means of correlation analysis of the particle magnetic rigidity, velocity and particle losses in spectrometer and TOF system. Some improvements of this method were implemented and are presented here. This improvements allows to enhance proton suppression and decrease systematic errors in calculation of number of deuterons.

First of all, truncated mean value of energy losses in tracker was used for deuteron separation instead of usual mean value. Truncation of energy measurements (vetoing of few maximum values) allows to make distribution of energy losses more "Gaussian" and more narrow and therefore to improve the different particles peaks separation.

Secondly, dE/dx values from six detectors of TOF system were used (instead of one value in original methodic). This addition gives an opportunity to improve proton suppression.

At last,  $1/\beta$  distributions (instead of mass to charge square distributions) for calculation of number of deuterons is preferable to use because it is "more" Gaussian than for other variables.

## 3. EFFICIENCY CALCULATION

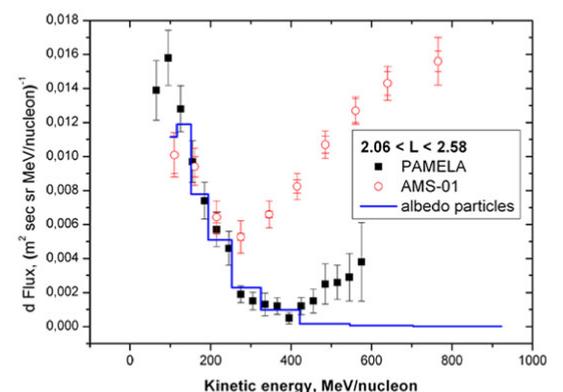
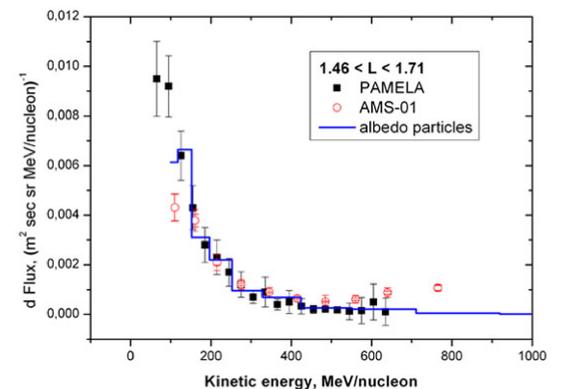
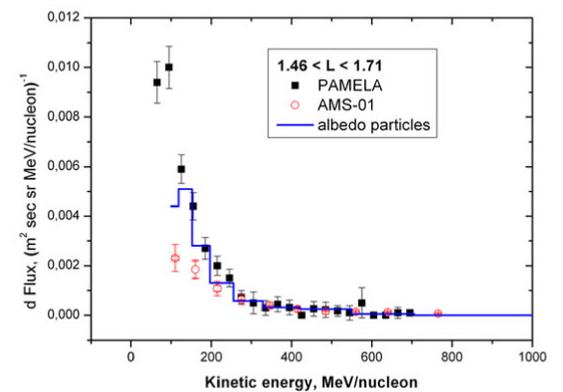
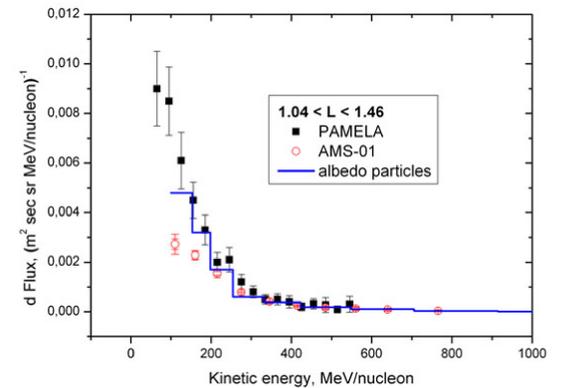
It's important to know the efficiency of particle selection to reconstruct spectrum. Efficiency was calculated using flight data by following way. Since few detectors were used for particle identification it is possible to use cross-detector efficiency determination. It means that, for example, the efficiency of TOF system can be calculated by analysis of tracker and AC system data. Some particles (e.g., deuterons) were selected from full data sample with help of procedure as described above, but with important addition: selection was made only by tracker and AC system, TOF system basic criteria and particle selection were discarded. The last steps were the implementation of TOF system basic separation criteria and efficiency calculation.

Efficiency of tracker system and AC system were calculated by in a similar manner.

Final apparatus efficiency was calculated by multiplication of AC, TOF and tracker systems efficiencies.

## 4. RESULTS

The measured deuteron spectrum for different intervals of L-coordinate in McIlwain system of coordinates can be found on the pictures on the right. There is easy to find the good agreement between obtained experimental data and the data from AMS-01 experiment and the theoretical predictions (L. Derome et al., Phys.Lett. B, 2001). Small discrepancies for small energies originate from different periods of solar activity and, therefore, different fluxes of primary cosmic radiation, which is the main source of albedo particles. On the last picture for geomagnetic coordinates  $2.06 < L < 2.56$  the effect of geomagnetic cutoff for energies more than 400 MeV/nucleon can be seen.



## PAMELA Collaboration Member List

Adriani O., Barbarino G. C., Bazilevs-kaya G. A., Bellotti R., Boezio M., Bogomolov E. A., Bongio M., Bonvicini V., Bottai S., Bruno A., Cafagna F., Campana D., Carbone R., Carlson P., Casolino M., Castellini G., Danilchenko I. A., De Donato C., De Santis C., De Simone N., Di Felice V., Formato V., Galper A. M., Karelin A. V., Koldashov S. V., Koldobskiy S., Krutkov S. Y., Kvashnin A., Kvashnin A. N., Leonov A., Malakhov V., Marcellini L., Martucci M., Mayorov A. G., Menn W., Merge' M., Mikhailov V. V., Mocchiutti E., Monaco A., Mori N., Munini R., Osteria G., Palma F., Panico B., Papini P., Pearce M., Picozza P., Pizzolotto C., Ricci M., Ricciarini S. B., Rossetto L., Sarkar R., Scotti V., Simon M., Sparvoli R., Spillantini P., Stozhkov Y. I., Vacchi A., Vannuccini E., Vasilyev G. I., Voronov S. A., Yurkin Y. T., Zampa G., Zampa N., Zverev V. G.