STUDY OF VARIATION IN ELECTRON AND POSITRON FLUXES IN THE PAMELA EXPERIMENT

e-mail: muratkishev1995@mail.ru
M.B. Kishev, V.V. Mikhailov behalf of the Pamela Collaboration
National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 115409, Moscow, Russia

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Abstract

The results of measurements of primary electron and positron fluxes variations with energies ranging from 50 MeV and up to several of GeV, by "Pamela" magnetic spectrometer on a board of the satellite "Resur-DK1" are presented. The measurements were made from July 2006 until December 2015, in the minimum period of the 23rd solar cycle to the middle of the maximum of the 24th cycle.

Introduction

Cosmic rays are modulated during the 11-year solar cycle. The change in polarity of helioshperic magnetic field leads to a change in the ratio of electron and positron fluxes [1,2]. O.Adriani et al. [3] presents the results of measurements of the fluxes ratio from 2006 to 2015 in energy interval from 0.5 GeV to 5 GeV. The purpose of this work is to study the ratio $e^+/(e^-+e^+)$ at low energies.

Experiment PAMELA

The experiment PAMELA (Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics), which was conducted aboard the Russian satellite «Resurs-DK1», was developed by the joint work of scientists from Russia, Italy, Sweden and Germany. The main research objective of the experiment is the measurement of antimatter fluxes. PAMELA records positrons and antiprotons in the energy ranges of 50 MeV - 270 GeV and 80 MeV - 190 GeV, respectively.

The PAMELA device includes: a magnetic spectrometer (track system 6 and a permanent magnet 7), a time-of-flight system (VPS) (1 (S1), 3 (S2), 8 (S3)), an anticoincidence (AC) system (2 (CAT), 4 (CARD), 5 (CAS), electromagnetic calorimeter (9), scintillation detector S4 (10) and neutron detector (11).

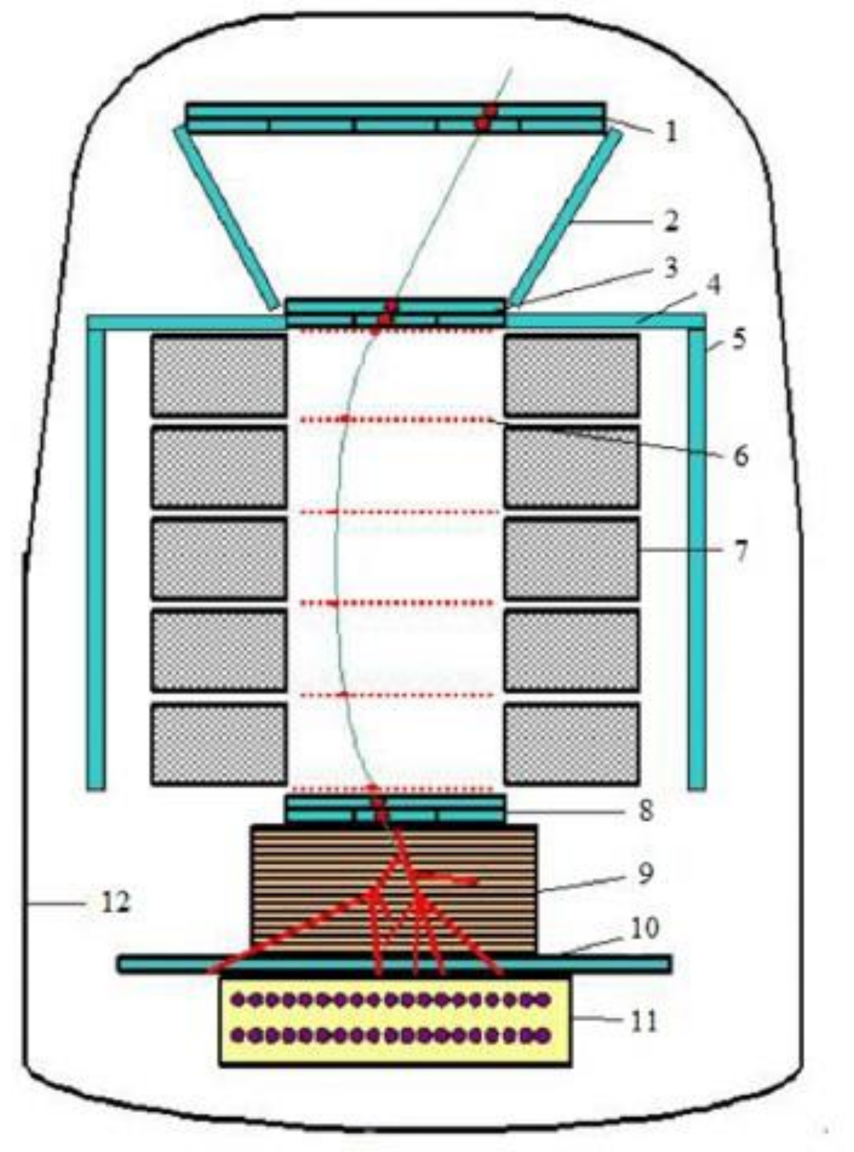

Fig. 1 Physical scheme of a spectrometer PAMELA.

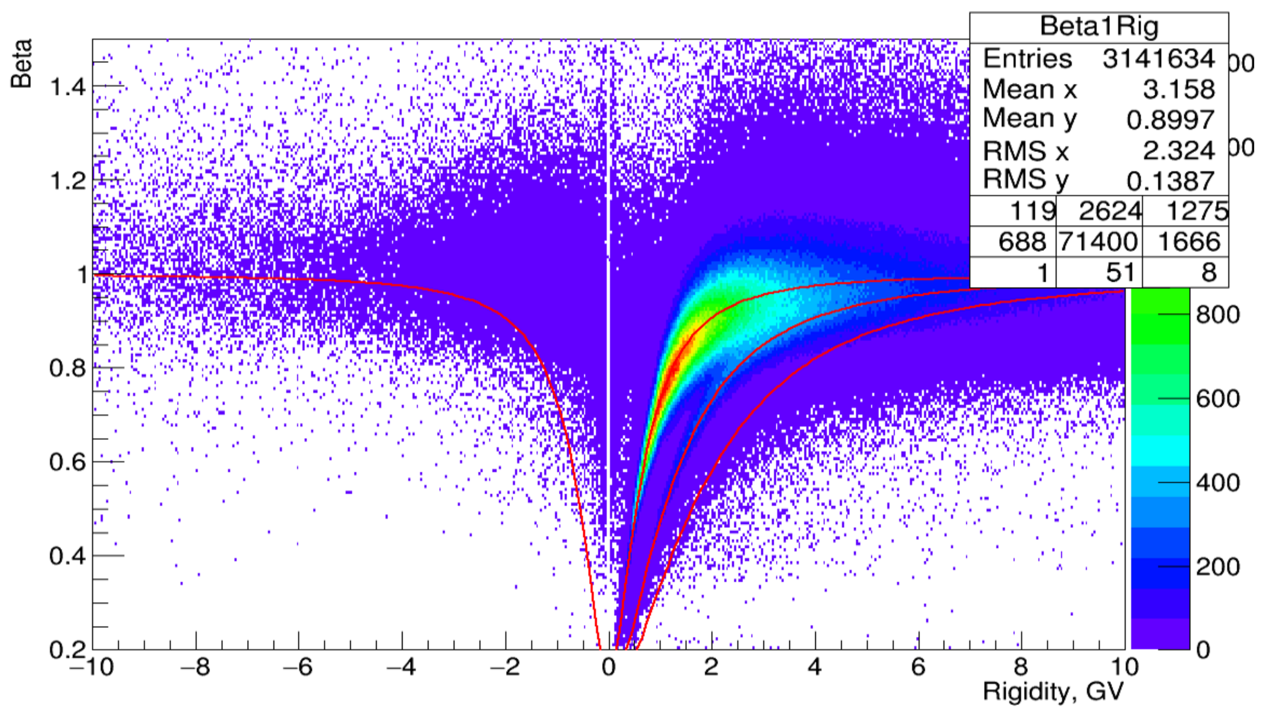

Fig. 2 Distribution on speed before selection

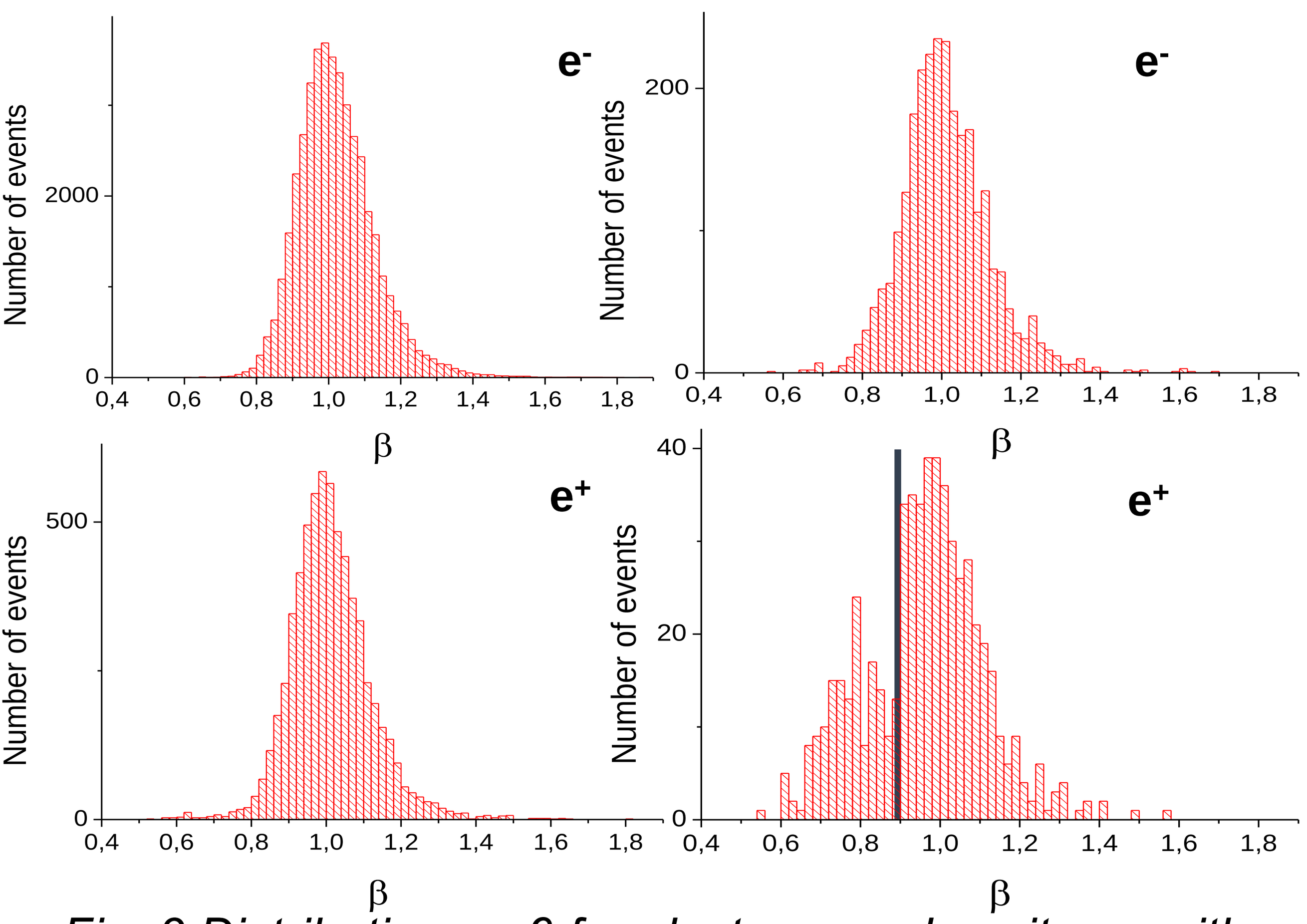

Fig. 3 Distribution on β for electrons and positrons with energy from 0.2 to 0.5 GeV on the left and with energy less than 0.2 GeV on the right

Selection of events

The main fraction of cosmic radiation is protons (about 90%) and helium nuclei (about 10%), while the total fraction of electrons and positrons is no more than 1%. Therefore, the selection of electrons and positrons against the background of protons and helium nuclei is especially important. The following steps have been implemented:

1.Single track selection. The particles that entered the magnetic spectrometer from above were selected by ToF (velocity β>0). In each of the scintillation detectors of the ToF, the signal appeared only in one paddle. With the help of the anti-coincidence system, events that generated in the container or parts of the device are excluded.

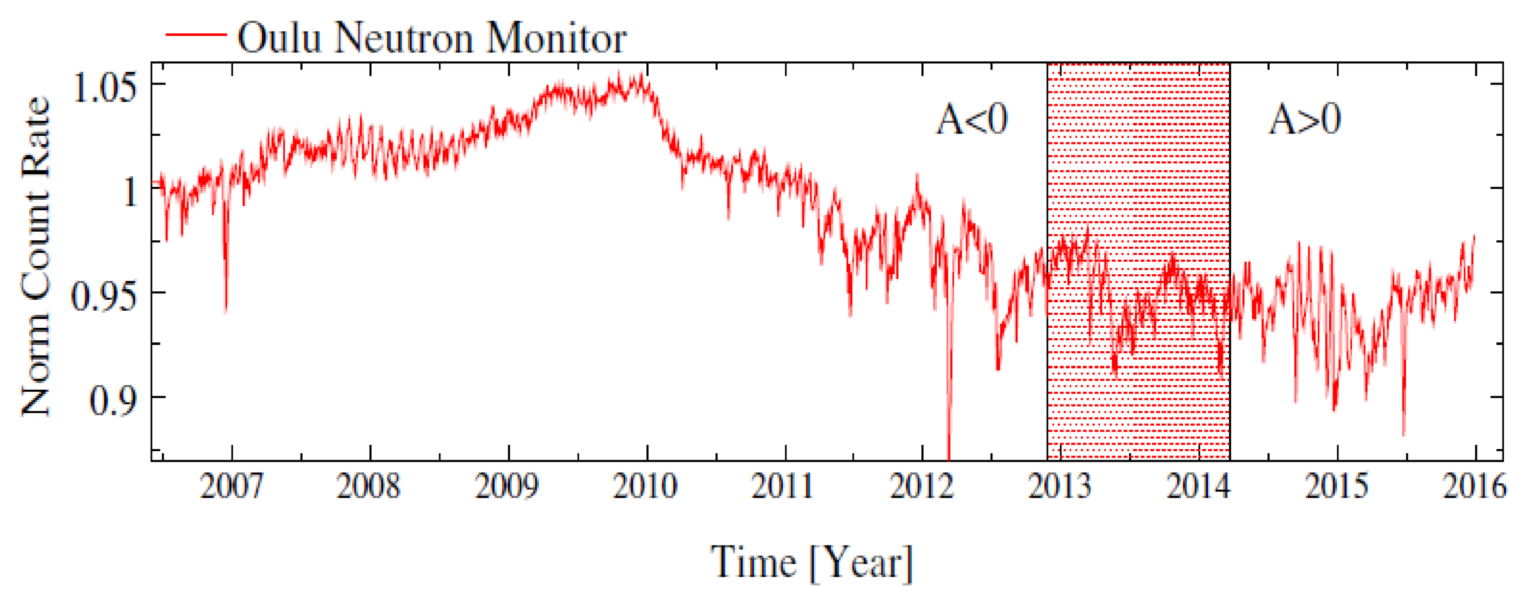

Fig.4 The neutron count rate in the period from July 2006 to the end of 2016

2. The type of particles was then determined. Sign of charge and rigidity was obtained by fitting track in magnetic spectrometer. Figure 2 shows the velocity distribution vs rigidity before selection. Significantly protons and cores of helium, in comparison with electrons and positrons prevail. By means longitudinal and transverse profiles of the cascade in the electromagnetic calorimeter electrons, positrons and protons were identified.

3. The additional suppression of the background events. The energy release in the counters S1, S2, S3 of ToF and, the scintillation detector S4 is considered. Events with neutron detector response are also excluded.

Distributions on speed for the selected electrons and positrons are shown in the figure 3. At an energy from 0.2 to 0.5 GeV impurities are minimal, and at an energy of less than 0.2 GeV, an additional selection for β > 0.9 is used for positrons.

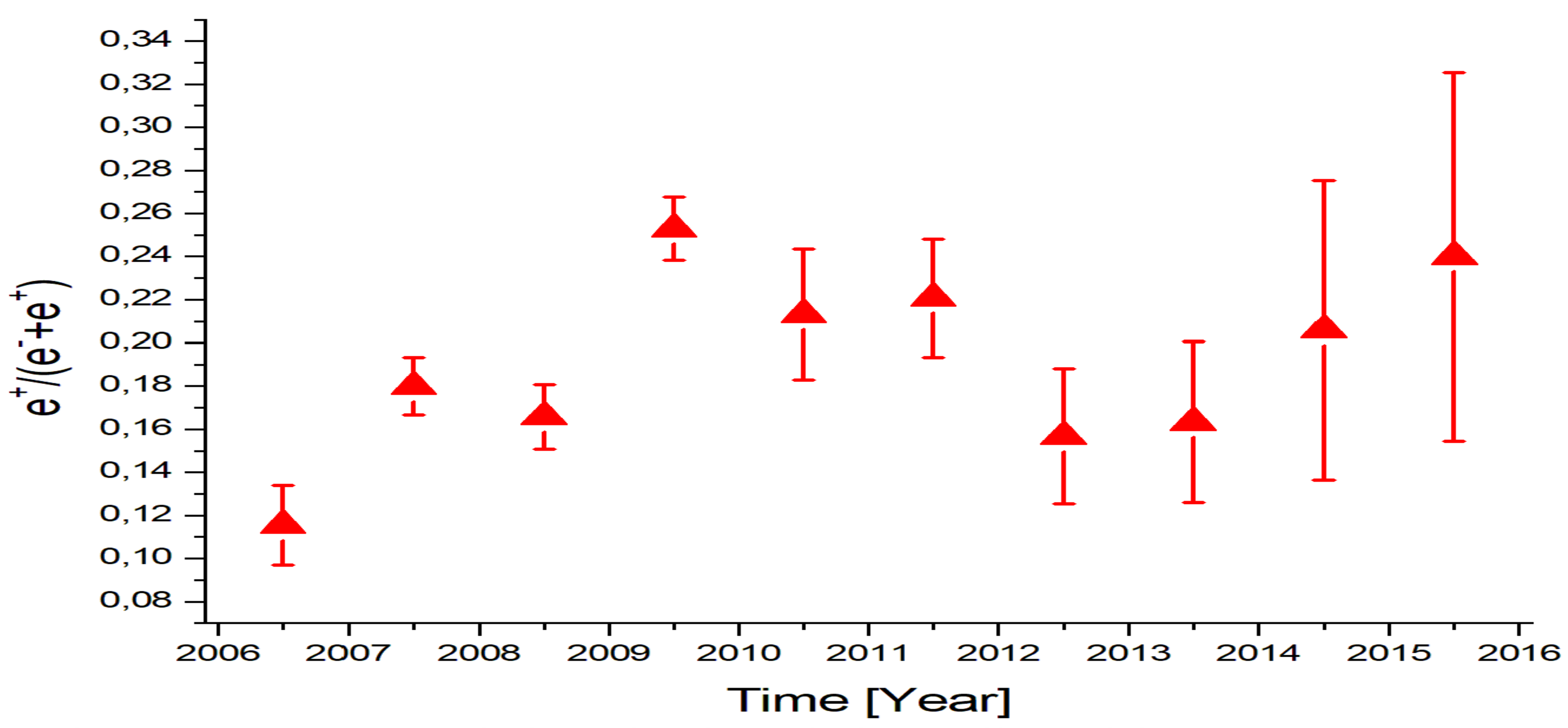

Fig. 5 Temporary variations for the relation $e^+/(e^-+e^+)$ in an energy rang to 200 MeV

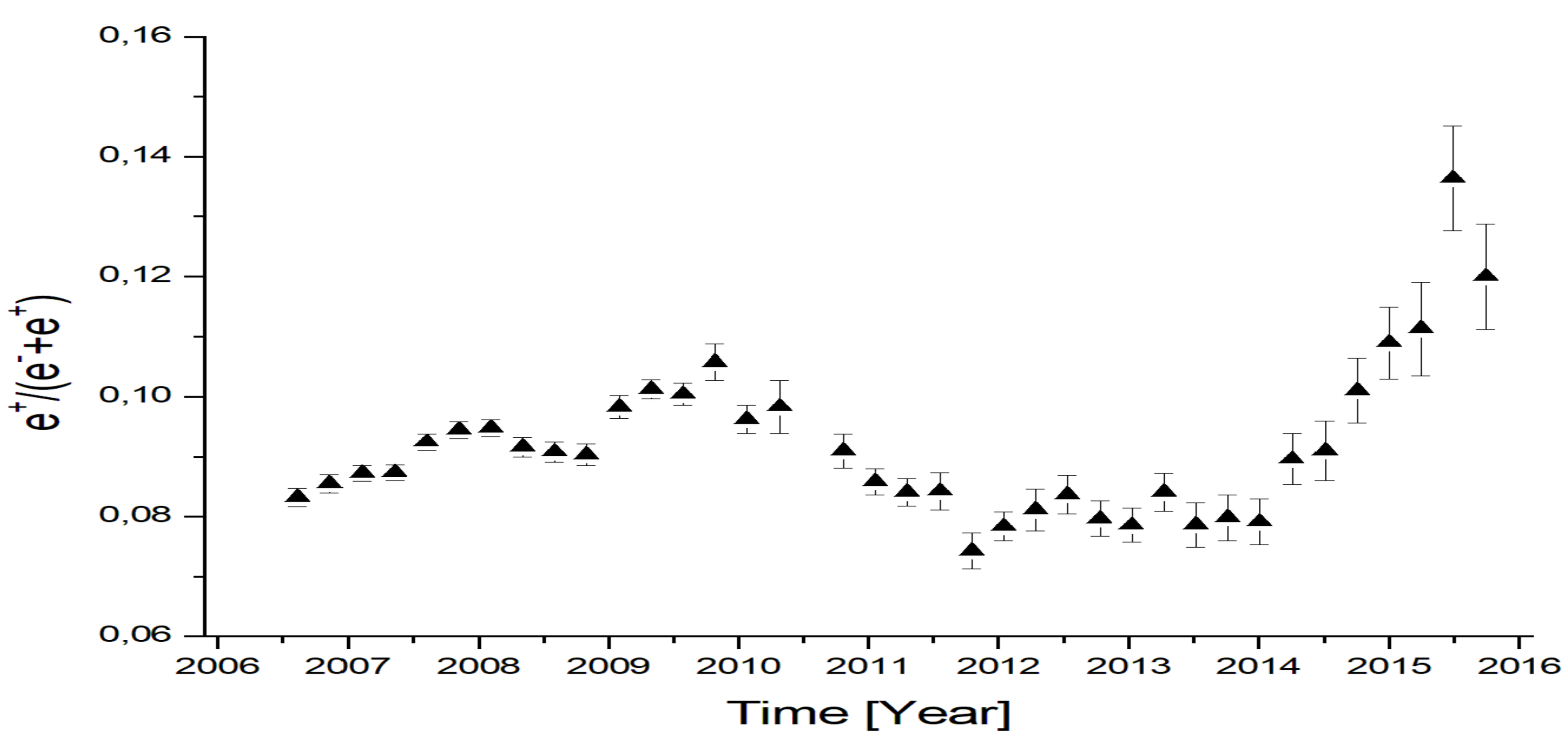

Fig. 6 Temporary variations for the relation $e^+/(e^-+e^+)$ in an energy rang of 0.5-2 GeV

Results

The measurements were taken with 2006-2015, the count rate of the neutron monitor Oulu during this period is shown in Fig. 4 [3]. The minimum of solar activity was at the end of 2009, and the maximum falls on the period from 2013 to 2014, where the polarity reversal occurred [3].

Electrons and positrons with rigidity greater than vertical geomagnetic cutoff rigidity in a point of detection for the entire period of measurements were selected. Temporary variations of the relation $e^+/(e^-+e^+)$ for energy ranges E< 0.2 GeV and from 0.5 to 2 GeV are given in the figure 5 and 6. Preliminary results of the experiment show that at energies less than 0.2 GeV the variations are not contradict with that obtained at high energies within statistical error.

References

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2. Potgieter M. S. Solar modulation of cosmic rays //Living Reviews in Solar Physics. – 2013. – T. 10. – №. 1. – C. 1-66.
3. O. Adriani et al. "Time dependence of the electron and positron components of the cosmic radiation measured by the PAMELA experiment between July 2006 and December 2015" PRL 116, 241105 (2016).