Energy spectra of protons and helium nuclei measured by the cosmic ray NUCLEON experiment


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Abstract

The NUCLEON satellite experiment is designed for direct measurements of the energy spectra of cosmic-ray nuclei and the chemical composition (Z=1-30) at an energy range up to 1000 TeV. The energy spectra of protons and helium nuclei are presented. Some spectral peculiarities were found. The differences of protons and helium spectra are investigated.
NUCLEON
KLEM (Kinematic Lightweight Energy Meter)
The image of the event. The nucleus initialized the shower. (1) - two pairs of charge measurement system planes; (3) - 6 planes of energy measurement system utilizing the KLEM technique; (5) - calorimeter
The image of the event. The nucleus initialized the shower.
The S-estimator is defined as:

$$S = \sum I_k \ln^2(2H/x_k)$$
Calorimeter energy deposition vs S estimator 
(experimental results)
Preliminary charge distribution obtained by the NUCLEON experiment. The resolution is near 0.2 charge unit.
Proton spectra

![Graph showing proton spectra with various data points and labels such as NUCLEON (KLEM), NUCLEON (IC), ATIC, SOKOL, CREAM-III, and AMS02.](image-url)
Helium spectra

Flux $\times E^{2.6}$ (m$^2$ s sr GeV$^{-1}$) (GeV)$^{2.6}$

- NUCLEON (KLEM)
- NUCLEON (IC)
- ATIC
- SOKOL
- CREAM-III
- AMS02

E GeV
p/He ratio
We assume existence of peculiarity in the proton spectrum ("bird")
Rigidity spectra. The possible break near $R \sim 10$ TV
Zatsepin & Sokolskaya model predicts breaks near $R = 10$ TV both in spectra of protons and helium, and in spectra of heavy nuclei.

CONCLUSION

• The obtained energy spectra show good consensus on two different techniques of energy measurements. Thus, operability of a new KLEM technique in the wide energy range is confirmed.

• The helium spectrum is more hard than protons one at energies >4 TeV.

• There are signs of a peculiarity of protons (“bird”) spectrum at 30-50 TeV/particle.

• There are signs of steepening of proton and helium spectra at energies >10 TeV.

• The NUCLEON experiment continues.
The satellite was launched 28.12.2014.
Rigidity spectra. The possible break near $R \sim 10$ TeV/Z

<table>
<thead>
<tr>
<th></th>
<th>$R &lt; 10$ TV</th>
<th>$R &gt; 10$ TV</th>
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<tbody>
<tr>
<td>$p$</td>
<td>$2.50 \pm 0.05$</td>
<td>$2.68 \pm 0.07$</td>
</tr>
<tr>
<td>$p$</td>
<td>$2.33 \pm 0.02$</td>
<td>$2.34 \pm 0.09$</td>
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$\Delta \gamma$