



Review of the Results from the NUCLEON Space Mission

The objectives of NUCLEON space experiment experimental study of cosmic ray spectra in the energy range from a few TeV - 1 PeV per particle with elemental charge resolution

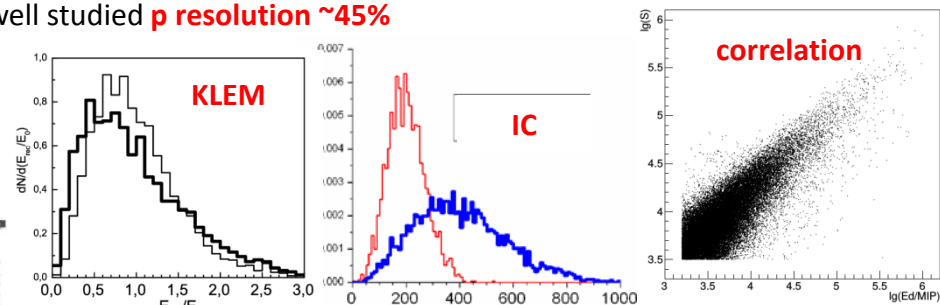
D. Podorozhny, V. Bulatov, S. Filippov, V. Grebenyuk, D. Karmanov, I. Kovalev, I. Kudryashov, A. Kurganov, M. Merkin, A. Panov, D. Polkov, L. Tkachev, A. Turundaevskiy, O. Vasiliev, A. Voronin

IMPORTANT FEATURE OF THE EXPERIMENT:

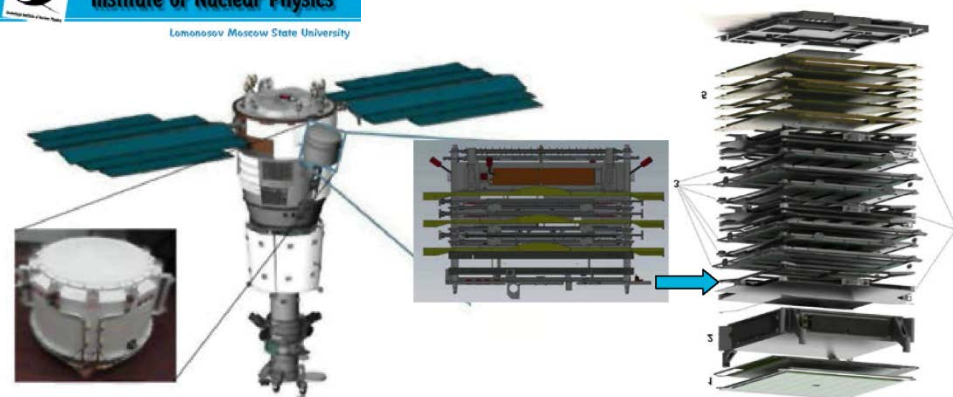
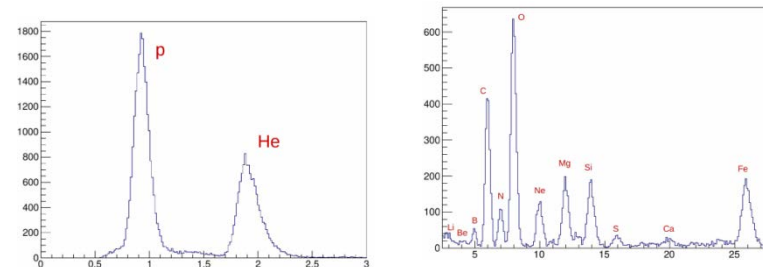
Two different methods of measuring of the energy of particles are implemented in the NUCLEON experiment:

1. The kinematic method KLEM (Kinematic Lightweight Energy Meter) - for the first time (main) **p resolution ~60%**
2. The calorimetric method – usual and well studied **p resolution ~45%**

Charge resolution of four silicon detector planes ~0.2 charge units in the range of $Z=1-30$



Correlation of the calorimeter and KLEM methods ~90%
This correlation is a model-independent result



Orbit is with inclination 97.276° and an average altitude of 475 km.
Weight ~360 kg, Power consumption ~160 W, TM ~10 GB/day

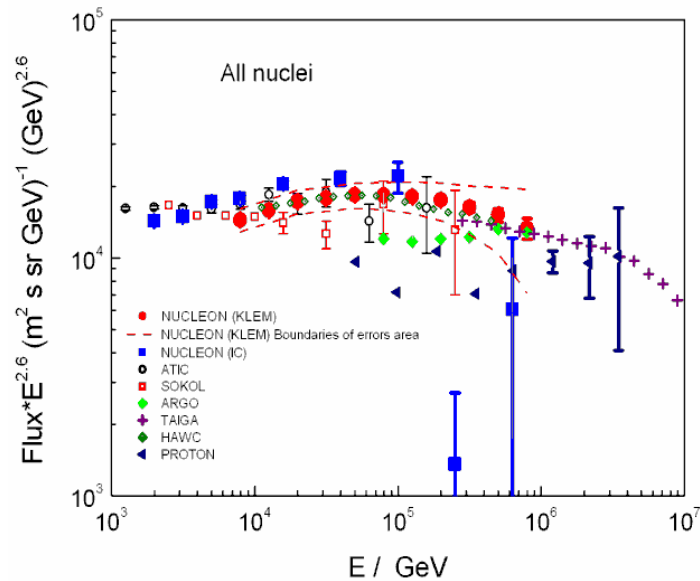
LiveTime(days) = 226.832

- (1) Charge measurement system – four planes of pad silicon detectors ($1.5 \times 1.5 \text{ cm}^2$);
- (2) Carbon target of 0.25 proton interaction lengths;
- (3) KLEM tracker – six planes of microstrip silicon detectors (0.4mm step) with tungsten inserted between them (~2mm each, ~3 X-lengths summary). Active square $500 \times 500 \text{ mm}^2$. KLEM geometrical factor $0.24 \text{ m}^2 \text{ sr}$.
- (4) Trigger system – tree double scintillator planes;
- (5) Ionization calorimeter (IC) – six planes of tungsten absorber (~8mm each, ~12 X-lengths summary) with silicon strip detectors (1mm step). Active area $250 \times 250 \text{ mm}^2$. IC geometrical factor $0.06 \text{ m}^2 \text{ sr}$

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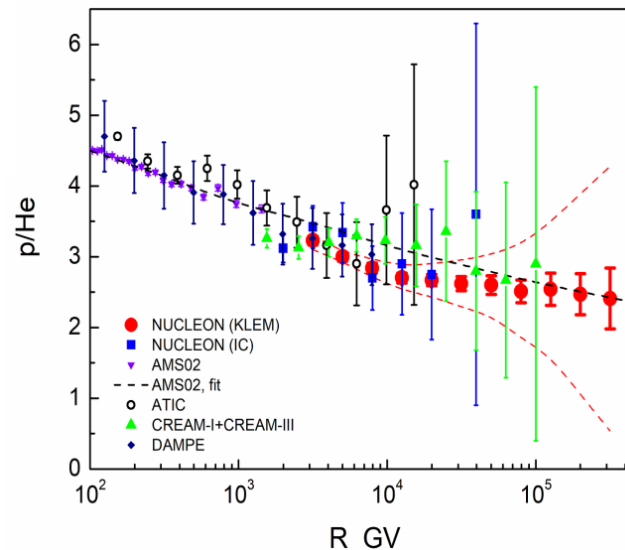
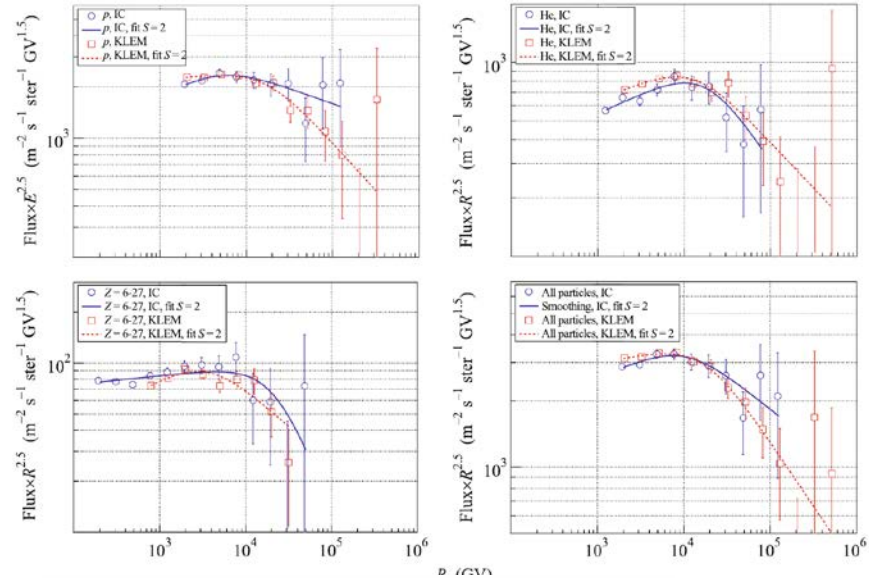
Main results of the NUCLEON Mission

For the first time, the all particles spectrum from direct measurements and from EAS are compared. The difference between the spectrum and the power-law approximation is apparent. With power-law fitting, the value of χ^2 per degree of freedom is 2.21

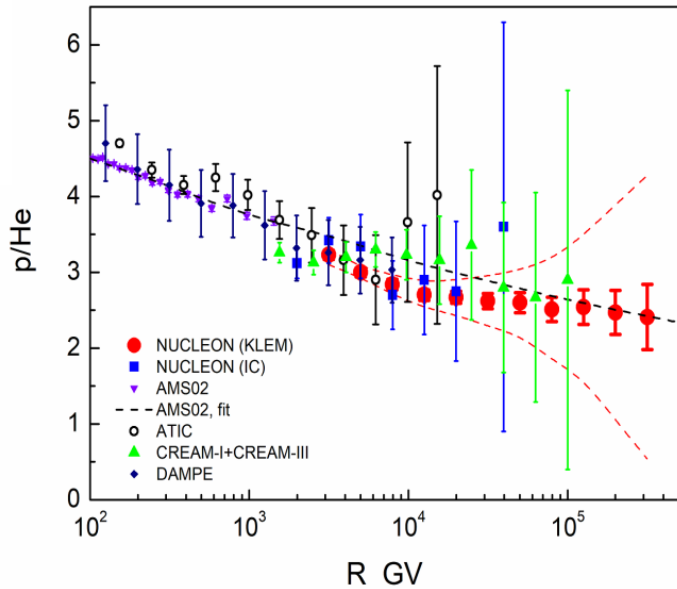


It has been proven for the first time with sufficient statistics that the ratio of the spectra of protons and helium decreases with increasing rigidity, but in the region of 10 TV it reaches a plateau

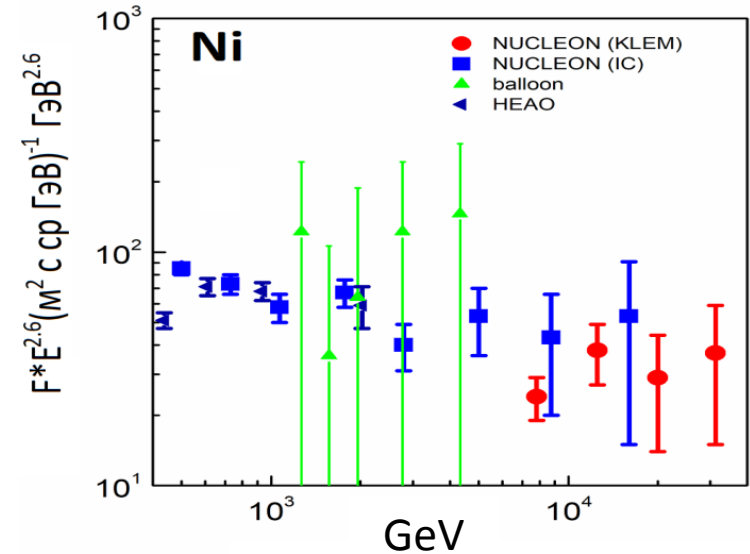
Break in spectra of all abundant CR components in the region of ~ 10 TeV / nucleon in magnetic rigidity was found. (More details in the report A.Panov et. al "10 TV knee of cosmic rays measured with the NUCLEON space experiment")



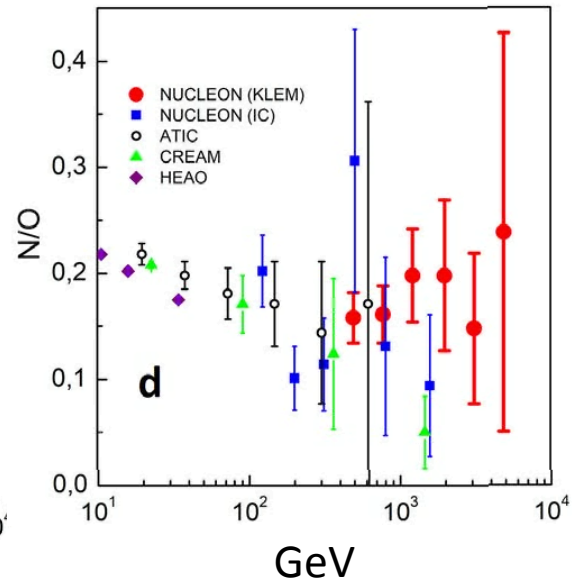
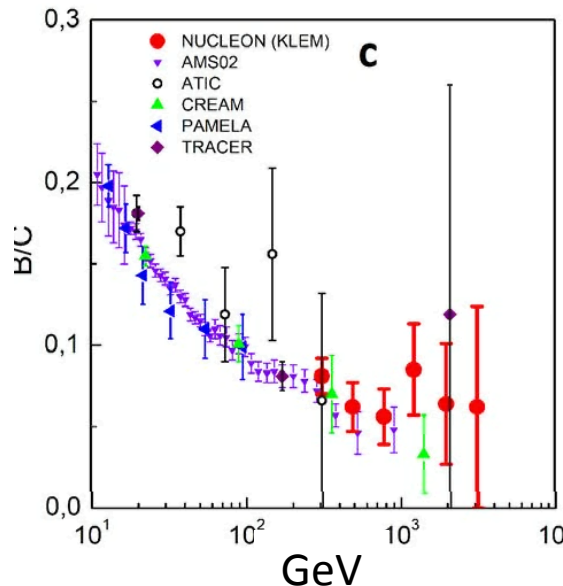
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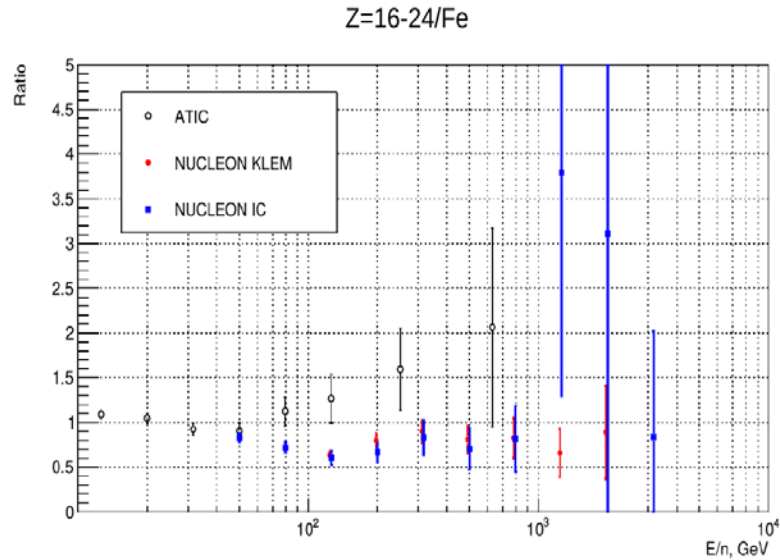
The spectrum of nickel nuclei of high energies up to 40 TeV was measured for the first time. The nickel spectrum has a slope of 2.83 ± 0.09 . This value differs from the slope of the spectrum of iron 2.64 ± 0.02 . The difference in these spectra may reflect the properties of nucleosynthesis and acceleration of cosmic rays.



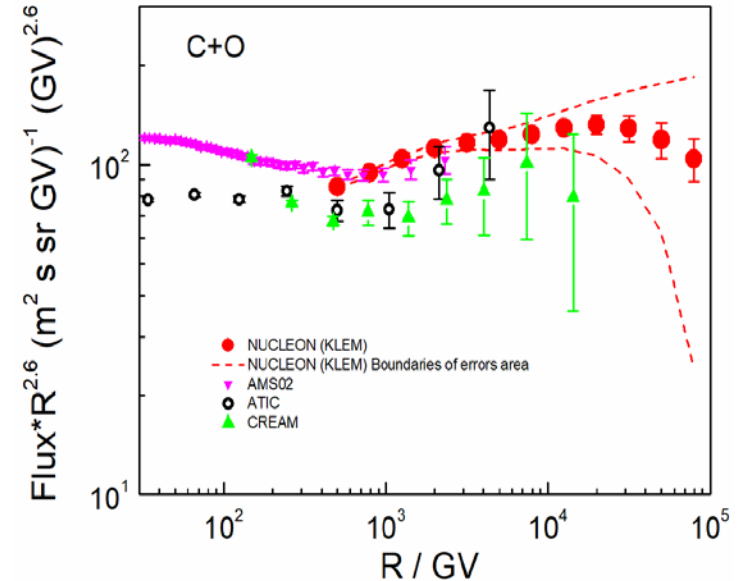
The spectra of secondary nuclei (according to modern theories, born during the fragmentation of abundant nuclei with the galactic medium) have been obtained and the energy dependences of their relations to primary ones have been constructed. In the data of the "NUCLEON" experiment, for the first time a statistically assured absence of a decrease in the intensity of secondary nuclei was found, starting from the energy region of 1 TeV / nucleon. This fact provides experimental confirmation of the model of fragmentation of abundant nuclei in sources and subsequent acceleration of fragments.



An indication of an increase in the intensity of the flux of secondary nuclei of the sub-Fe group to the flux of abundant Fe nuclei with increasing energy was obtained. This phenomenon currently has no astrophysical explanation. According to modern theories, the ratio of flows should be opposite.



The extension of C, O nuclei spectra obtained in the AMS-02 experiment in the $R=10^3-10^5$ GV region indicates spectrum flattening



The analysis of the NUCLEON data is still in progress!