NUCLEON Satellite Mission. Status and Plans

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Abstract

The main objective of the NUCLEON satellite mission is direct measurements of the elemental energy spectra of high-energy (10^{11}-10^{15} eV) cosmic rays with Kinematic Lightweight Energy Meter (KLEM) device. The design of the instrument has been corrected to increase geometry factor. The special mechanical and electronic systems have been developed for installation of the experimental apparatus in a regular Russian satellite. It is planned to launch the NUCLEON instrument in 2006.

1. Introduction

The NUCLEON satellite mission is the first stage of the program aimed to perform direct measurements of the elemental energy spectra of high-energy

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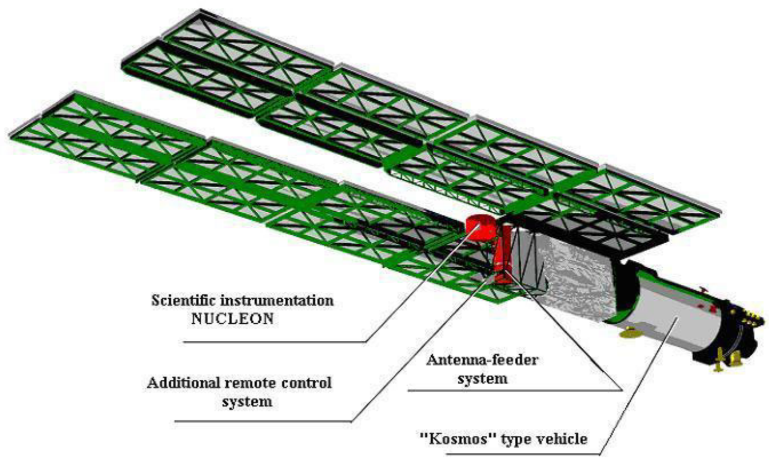

Fig. 1. KOSMOS type satellite with NUCLEON system.

cosmic rays. KLEM device [1,2] is a basic element of the instrument. It's size and geometry factor are relatively small (36×36×20 cm^3 and 0.19 m^{2}sr correspondingly) because of a weight limitation. We expect to reach 10^{15} eV energy during 2 year exposure. This device will be launched with a regular Russian satellite free of charge. Therefore, the NUCLEON mission is supposed to be a rather cheap pilot experiment, which is expected to be followed by a large area (4-6 m^2) KLEM system launched by a special satellite in 2009-10.

2. Whole System Development

Special mechanical/electronic system has been developed for scientific equipment installation and functioning with regular satellite. It includes a pressurized container for KLEM instrument, mechanical unit, which supports scientific device, additional remote control system in its own pressurized container, cooling system, antenna-feeder system, etc. It weights ∼150 kg. Electronic system allows data transmission of 24 Mbyte per day. The whole system can be fixed on a regular Russian KOSMOS type satellite (Fig. 1) or on a new type serial space vehicle.

3. R&D Results

R&D performed in 2002 have been aimed to increase geometry factor and reduce the number of electronic channels. According to the corrected design (Fig. 2) total thickness of the device reduced from 30 to 20 cm and geometry factor became 0.19 instead of 0.11 m^{2}sr. There is no empty space between the target and gamma-converter now. The target is subdivided into ten 1 cm thick layers of carbon with 0.5 cm layers of scintillating strips in between and below, which also

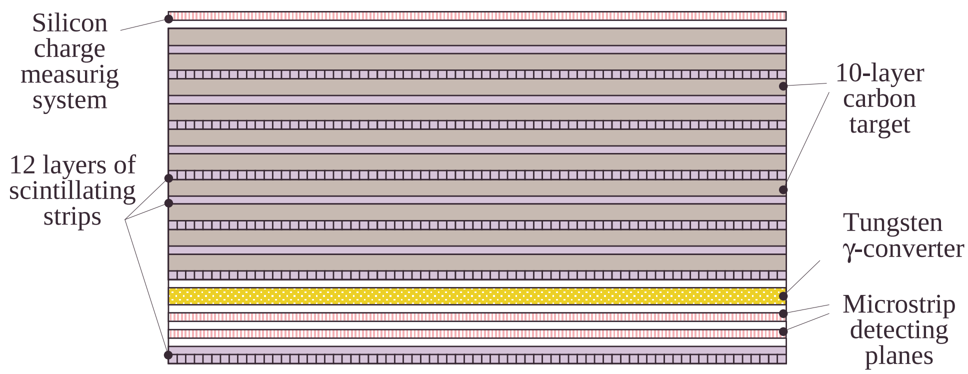

Fig. 2. NUCLEON device structure.

work as an active target. This structure allows interaction point determination with accuracy less than 0.5 cm in Z direction.

With knowledge of distance between interaction point and microstrip detecting planes we can select a particular algorithm for each layer of the target. Due to the algorithm corrections expected energy resolution is impaired for about 10% only. An advantage of increased geometry factor completely overrides the minor loss of energy resolution because more data can be collected [3,4].

Internal layers of scintillating strips can be used to generate more sophisticated trigger if data flow becomes too high for reliable transmission.

Microstrip pitch optimization has been done. Theoretically such small pitch as 25 μm looks preferable because secondary particle distribution can be well determined even for highest energies. But 25 μm pitch corresponds to 28800 electronic channels for double layer detecting plane 36×36 cm^2. If 50×50 cm^2 device can be launched 40000 electronic channels are needed for detecting planes only. But it is too many because of power limitation.

The simulations show that strip pitch can be increased up to 300 μm without essential degradation of energy resolution. But for energies above 10^{14} most of secondaries are concentrated in very small circle about 200-400 μm in diameter. Therefore it was decided to select a compromised pitch about 100 μm. This case the number of channels becomes 4 times less than with 25 μm pitch and meets the power requirements. On the other hand, if central area of a shower hits a bad strip, essential fraction of the shower is still present in both neighbor strips. It allows rather good interpolation for a total number of secondaries and their distribution and consequently good energy determination.

4. Scintillating Strip Development

Serious R&D and tests of scintillating strip and readout electronics have been performed at JINR, Dubna. The results are presented at this conference [5].

5. New Simulations

New simulations have been performed. They based on a real device structure and include all surrounding material. Expected proton and ion fluxes were taken into account for energy spectra reconstruction. Different trigger criteria were investigated. The results are presented at this conference [6].

6. Tests

One test of KLEM prototype has been performed at CERN in 2001. It has shown a good agreement between simulations and experiment. Further tests are planned for 2003 [2].

7. Plans

NUCLEON project R&D should be finished in 2003. Construction stage will be started in 2004 and finished by the end of 2005. Completely assembled device should be tested in the first half of 2006 and ready for a launch in the second half of 2006.

Acknowledgments

This work is supported by ROSAVIACOSMOS (contract # 808-0418/03) and Russian Foundation for Basic Research (grant #01-02-16611).

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