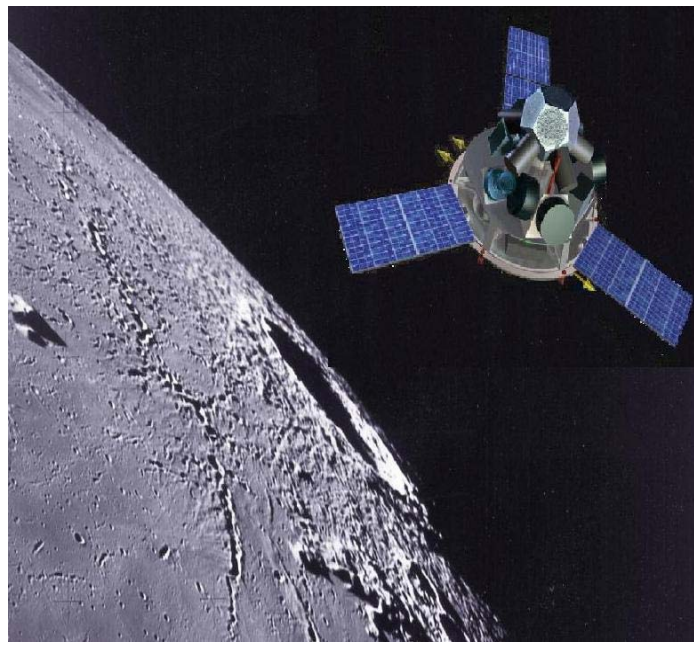
LORD (Lunar Orbital Radio Detector) Space Experiment for Investigation of Ultrahigh Energy Cosmic-ray Particles

- **Investigating the nature of the most energetic cosmic particles ($E \geq 10^{20}$ eV) in the Universe is one of the "hottest" problems of modern science. The study of ultrahigh-energy cosmic rays and neutrinos opens a unique possibility to explore particle physics within the extremely high energy scale.**
- **The ability of present-day and future experiments to detect ultrahigh-energy cosmic rays (UHECRs) is limited by the aperture of detectors in use. It could be quite possible that apertures of the Auger, Telescope Array, and even JEM-EUSO detectors would be insufficiently large to reliably detect UNECRs of energies $E_{CR} \geq 10^{20}$ eV (if they exist in the Universe).**
- **In order to detect cosmic rays and neutrinos of energies $E \geq 10^{20}$ eV, new methods based on novel principles are required.**
- **In recent years, a method proposed by G. Askarian as early as in the beginning of 1960s , and based on the detection of coherent Cherenkov radio emission arising from cascades generated by ultrahigh-energy particles has become wide-spread.**
- **The most important advantage of this method is the possibility to exploit huge target volumes transparent to radio emission.**
- **The idea to employ the Moon as a target for detecting UHECRs and UHENs by the radio method was first proposed by G. Askarian. In essence, production of cascades and generation of radio emission occur in the near-surface layer of the lunar soil, viz. in the radio-transparent regolith that consists of small stones ejected as a result of meteorite impacts with the Moon. Usually, the depth of the regolith attains 10 to 30 m.**
- **Radio emission is generated in a wide frequency band by a cascade initiated by an ultrahigh-energy particle within the solid angle close to the Cherenkov angle. A part of the radio emission after refraction at the "regolith-vacuum" interface escapes the lunar soil and can be registered by a radio telescope.**
- **As the Moon has no atmosphere, both UHECR and UHEN interactions with the lunar soil can be detected.**

LORD experiment for UHECR and UHEN observation using circumlunar satellite

We for the first time have proposed to detect radio emission from UHECRs and UHENs on the base of a circum lunar satellite in the framework of the LORD experiment.



In the LORD experiment, the Moon will be use as a target for UHE particle interactions. The main merits of such experiment:

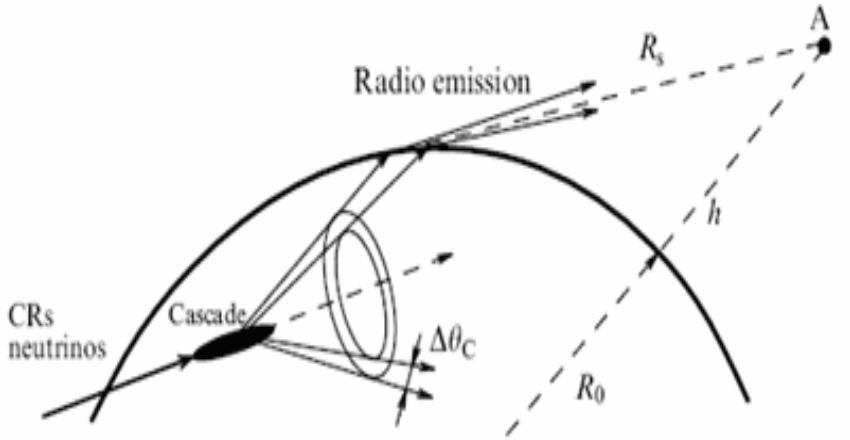
First, it is huge target mass, which can be surveyed using satellite-borne antennas $V_{eff} \sim 10^5$ (km.w.e.)^3.

Second, it is short (and variable, in principle) distance *L* from a few hundreds of km (instead of about 400000 km for observation from Earth).

Third, it is very favorable background conditions. The Moon has no atmosphere and magnetic field, therefore both UHECR and UHEN can be detected.

Conceptual design of the LORD experiment

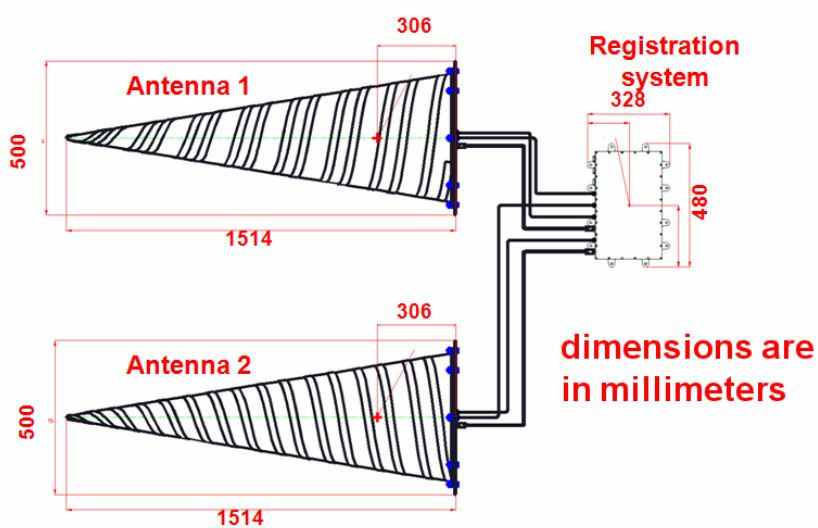
- **An incident particle interacts with the lunar regolith and gives rise to a cascade whose excess negative charge generates the Cherenkov radio emission propagating within a cone of the semiangle $\Delta\theta_C$.**
- **The radio wave crosses the lunar surface, and then being refracted according to the laws of geometric optics, propagates in space for a large distance R_s.**
- **By reaching the antenna A aboard the spacecraft at the altitude *h*, the radio emission can be registered by the detector.**

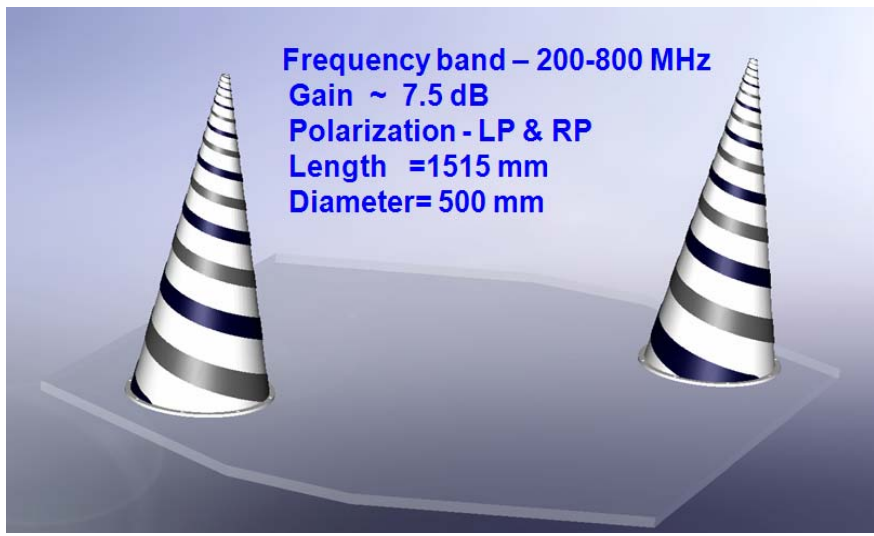


- **High of orbital – 500-700 km**
- **Exposition Time ~ 2 years**
- **Energy of range > ~ 10^{20}eV**
- **Effective aperture ~ 10^5 km^{2}sr**

Conceptual design of the LORD antenna system

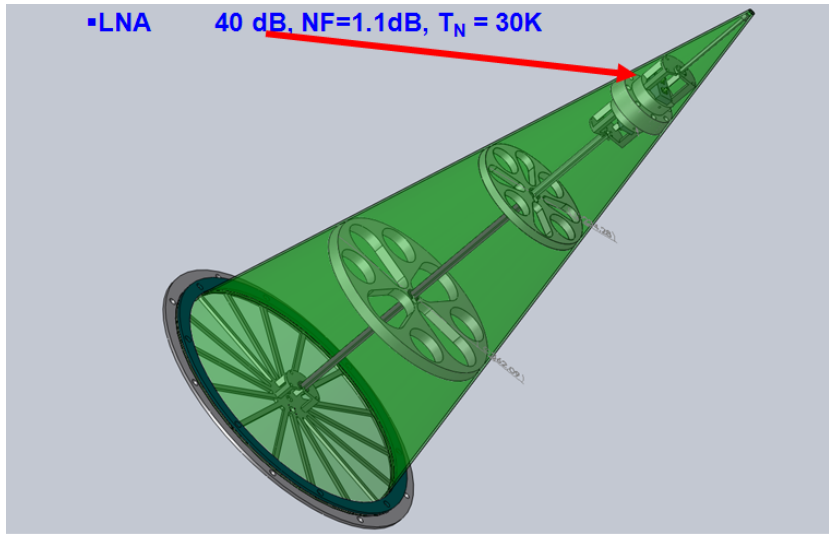
- The antenna system of 7.5-dB gain consists of two log-periodic spirals for two opposite circular polarizations.
- Depending on observations, the frequency band can be optimized for a high signal-to-noise ratio with the goal to increase the statistics of events.

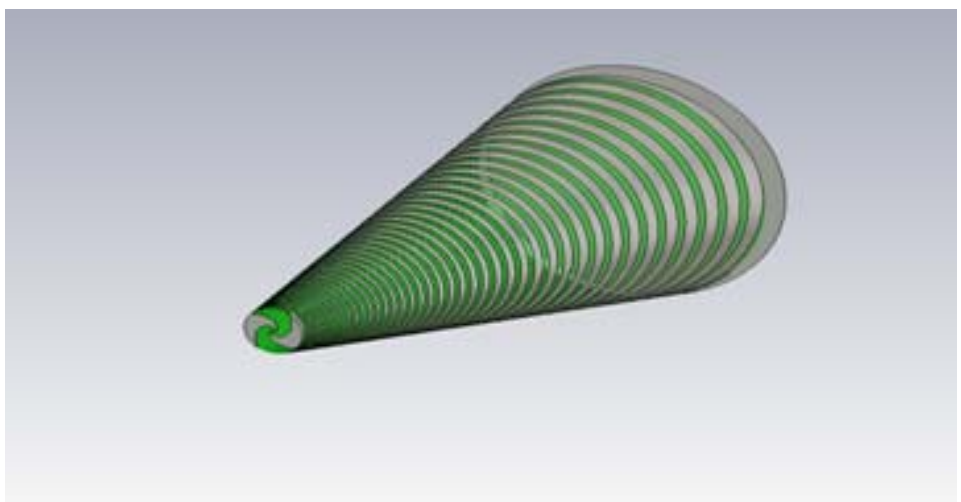


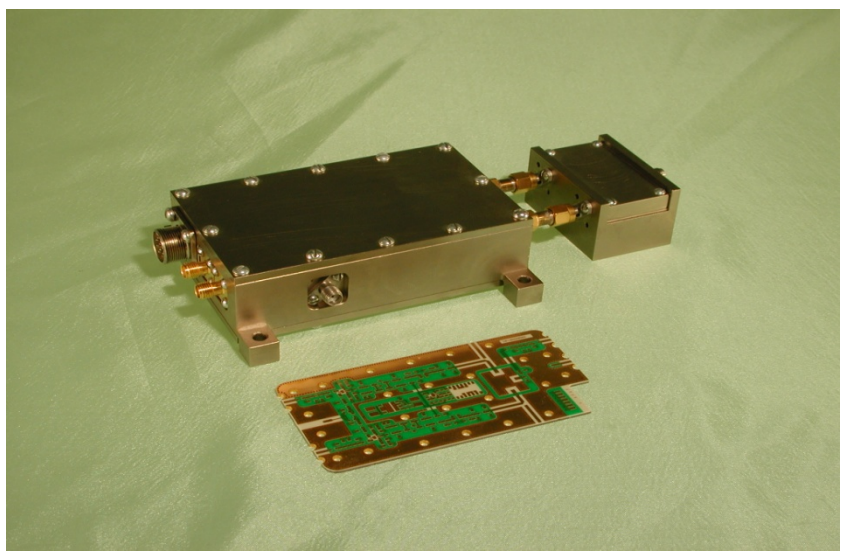


Conceptual design of the LORD antenna with low-noise amplifier

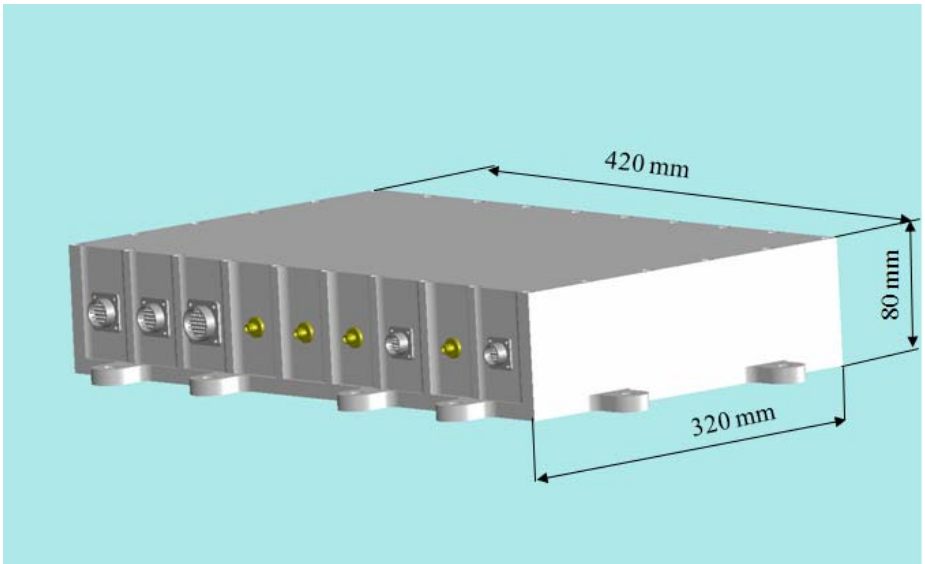
- **The low-noise amplifier has the gain of about 30 – 40 dB and the noise factor of 1.1 dB.**



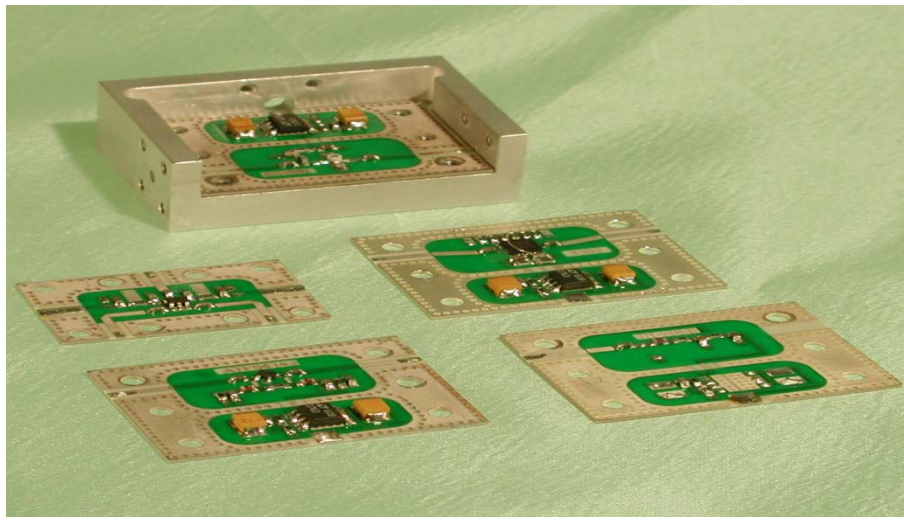


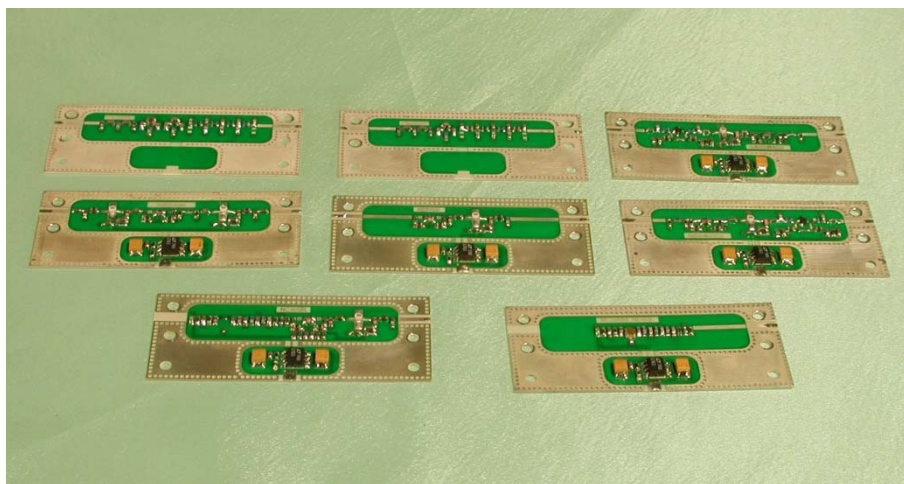


Registration block of the LORD equipment and elements of the analog electronics

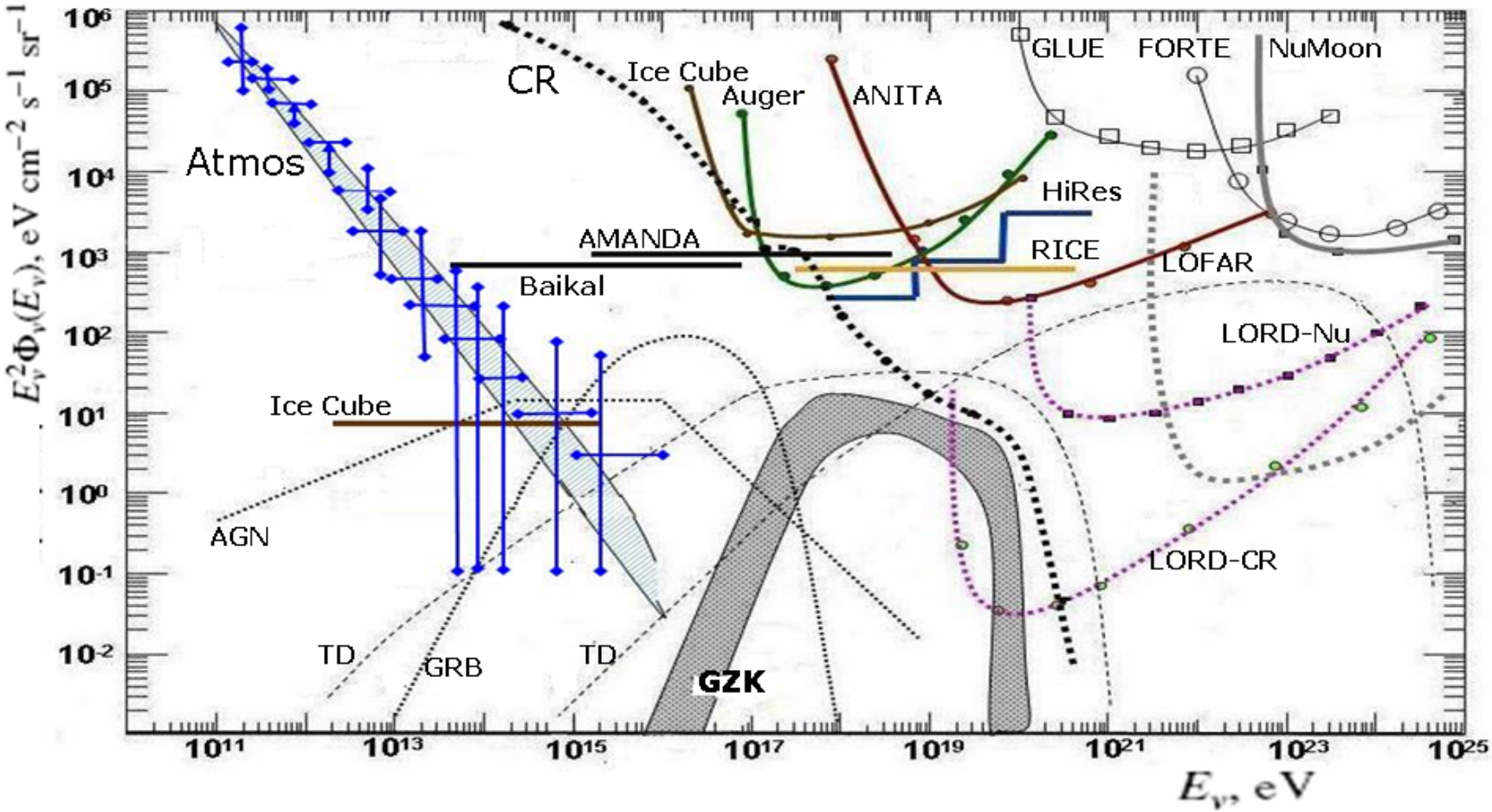


L×W×H =
420 mm ×320 mm×80 mm,
Weight= 12 kg,
Power Supply = 27 V, 60 W



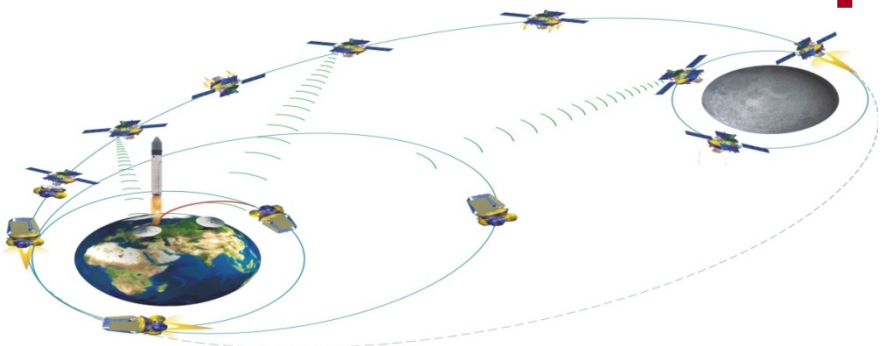


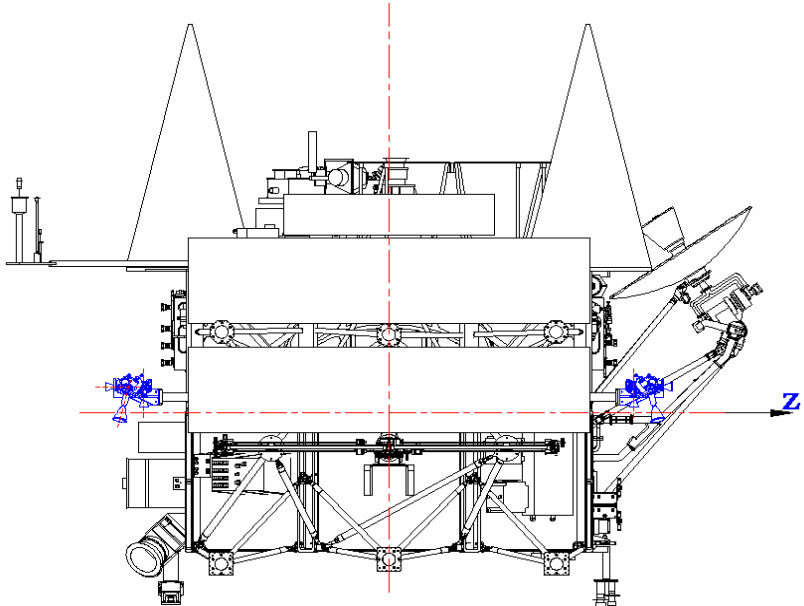
Limits for CR and neutrino fluxes



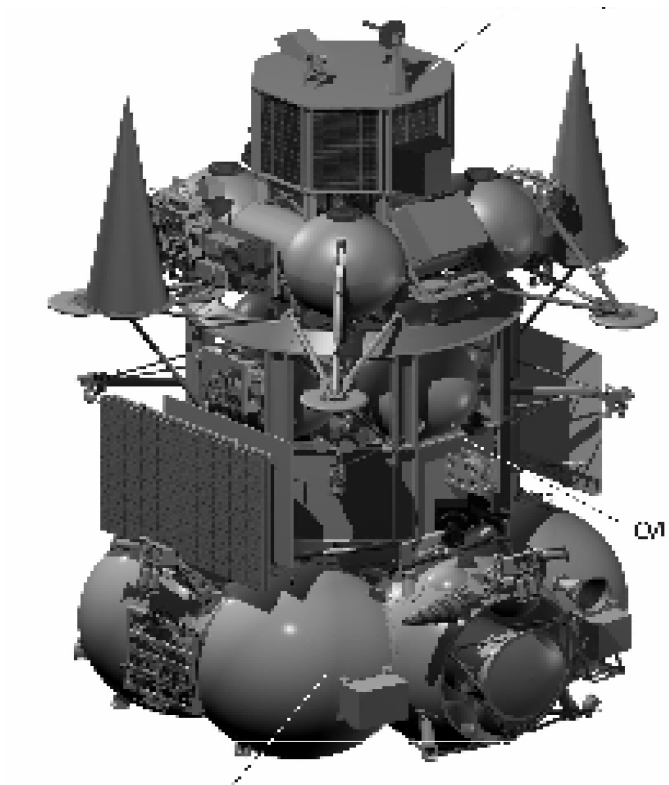
Results obtained for different experiments and projects associated with ultrahigh energy cosmic-ray and neutrino detection. As is seen in the energy range above 10^{20}– 10^{22} eV, the performances of the LORD are the best.

Luna-Glob space mission planned for launch in 2016 involve the LORD experiment.





Flight Module of Luna-Glob



Lay-out of Luna-Glob Apparatus