Reformatting a combined muon - neutron detector to increase efficiency: estimates, calculations, experiments

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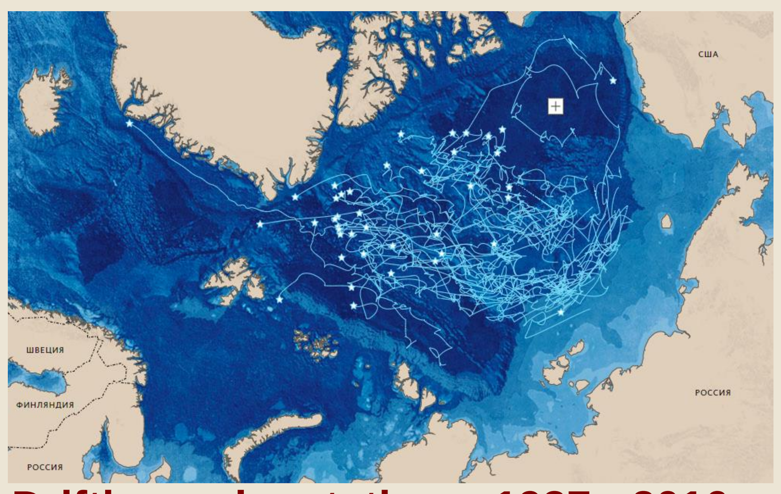
1. Objectives and methods. Muon telescopes and neutron detectors are skillful tools for measuring cosmic particles with energies> 400 MeV and expanding the upper limit of energies measured by cosmic ray detectors in outer space. Thanks to good statistics, these detectors are able to measure even weak anisotropy associated with solar and galactic cosmic rays. To date, all the most reliable information on anisotropy has been obtained from measurements of ground-based detectors based on various variants of globally spectrographic methods methods involving data from world-network detectors, including high-latitude and polar detectors playing a special role.

2. Introduction. Since 1937, conducted 41 polar expedition. Despite the many kilometers of ice floes several meters thick, one of the most frequent reasons for the termination of the expedition is the split of the platform or its destruction. Moreover, global climate change processes lead to objective difficulties for the organization of the North Pole stations on ice platforms.

Drifting station "North Pole" in 1937 and 2009

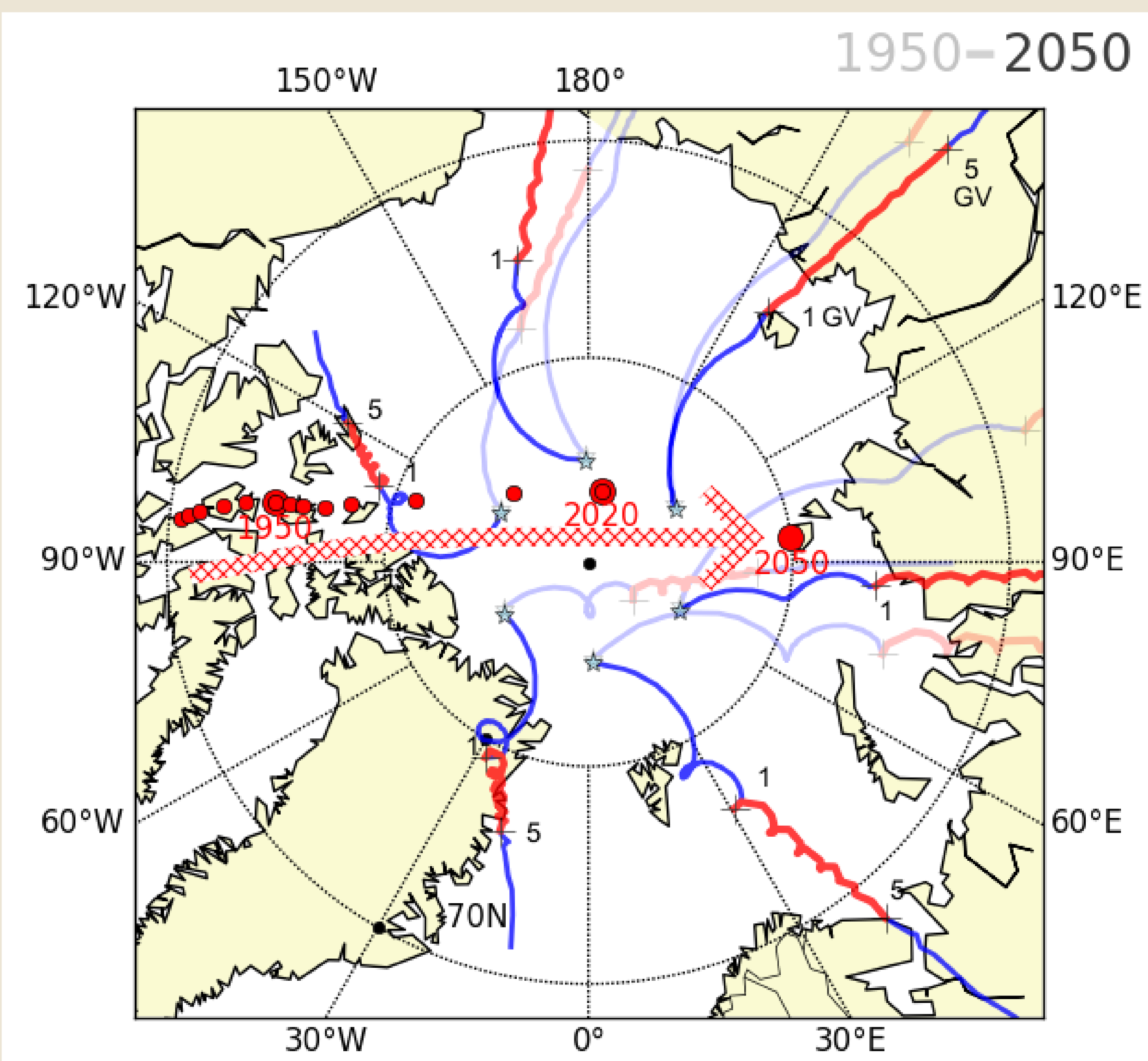
3. Drifting cosmic ray station and possible routes. Another way is to create an all-season, self-propelled, Arctic-class platform for year-round expeditions. This means the opportunity to work in the Arctic ice with their thickness up to 2-3 meters.



Drifting polar stations. 1937 - 2016.
★ - the end point.
https://ria.ru/infografika/20151109/1317148408.html

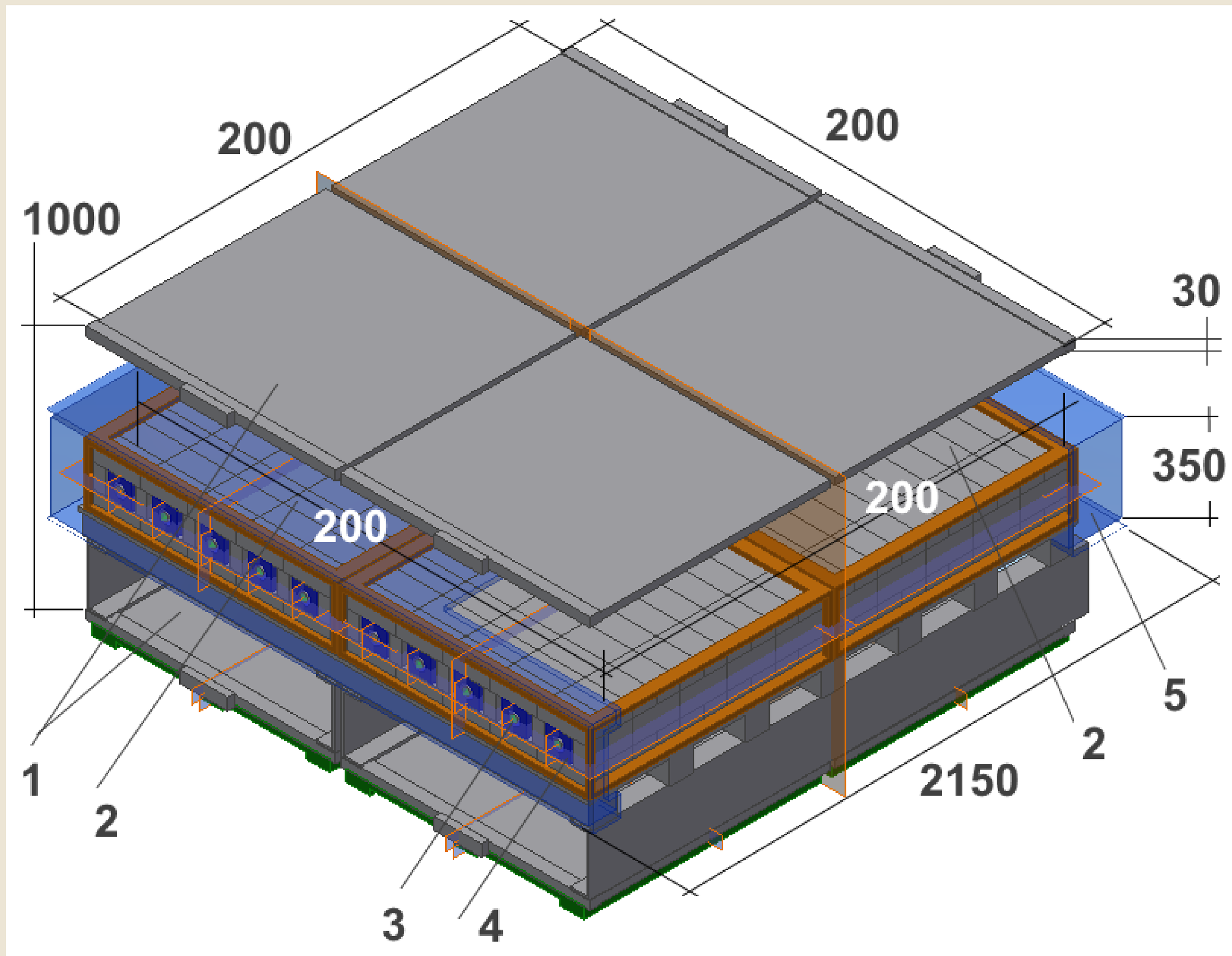
All-season self-propelled platform. Planned date of entry 2020
Arrow - a container of detectors in the stern of the vessel.

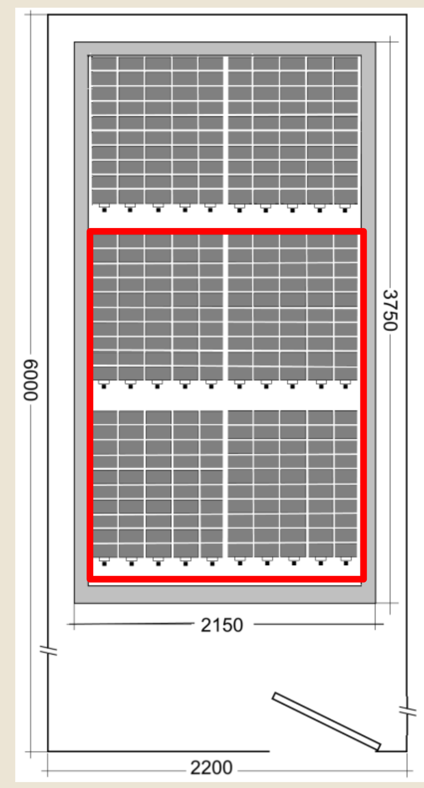
4. Features of the monitoring of cosmic rays in the Arctic Ocean and the magnetic poles drift. Detectors near magnetic poles collect cosmic radiation from polar directions, such detectors are ideal for isolating north-south anisotropy. High-latitude detectors are a tool for accurate measurements of the anisotropy of solar cosmic particles, since such detectors have excellent angular resolution and collect cosmic radiation from the ecliptic plane.



http://wdc.kugi.kyoto-u.ac.jp/poles/polesexp.html.
Comparison of asymptotic directions for 6 points at a latitude of 85ºN (the distance to the geographic pole is ~ 500 km) for two epochs of 1950 and 2050 every 60º in longitude. On each asymptotic curve, a hardness range of 1–5 GV, characteristic of solar cosmic rays, is distinguished.
The chain of points 1950 ... 2050 is the expected trajectory of the pole.

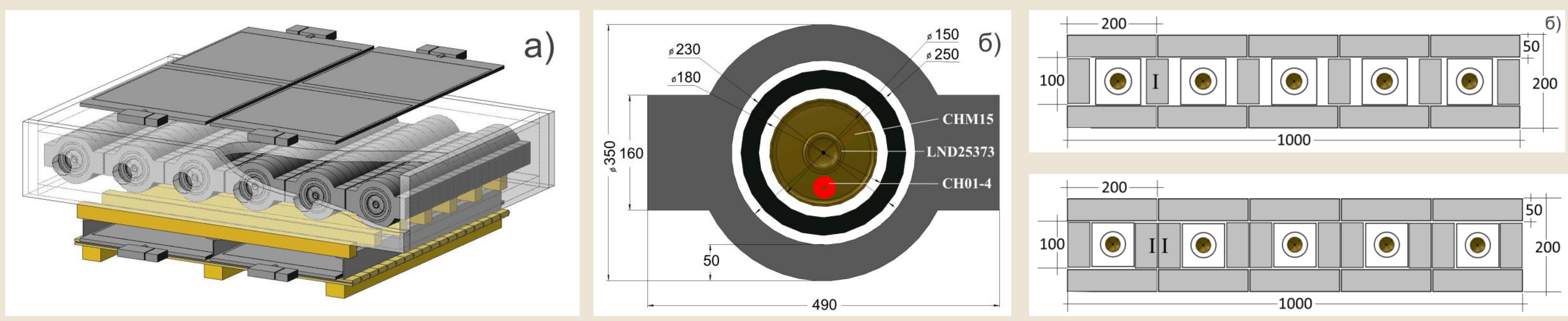
5. Design options for station detectors? "North Pole".
The maximum weight for installation on the upper deck of the ship is one section of the neutron supermonitor. Therefore, the question arises - is it possible to improve the statistics of the detector due to its reformatting and the use of more sensitive neutron counters? Estimates and GEANT detector modeling give a positive answer to the question posed.





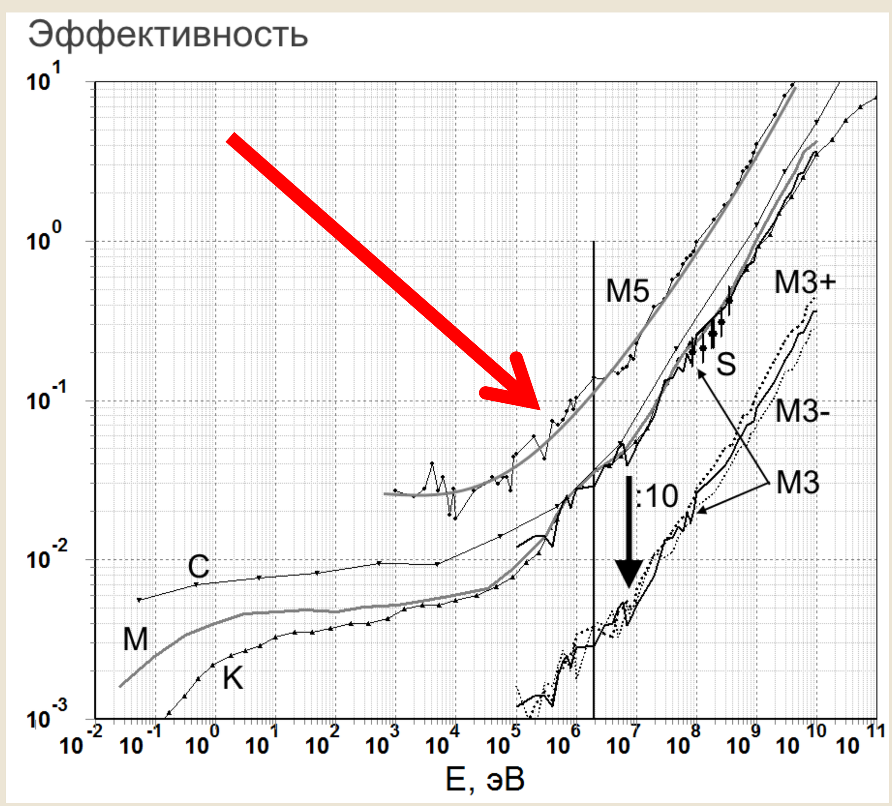
Visualization of the model of a combined muon telescope – neutron monitor. Muon telescope: 1- scintillation counter SC-301; 2 - lead filter cosmic ray soft components. Neutron monitor: 2 - lead neutron generator; 3 - proportional neutron counter; 4- polyethylene retarder; 5 polyethylene reflector.

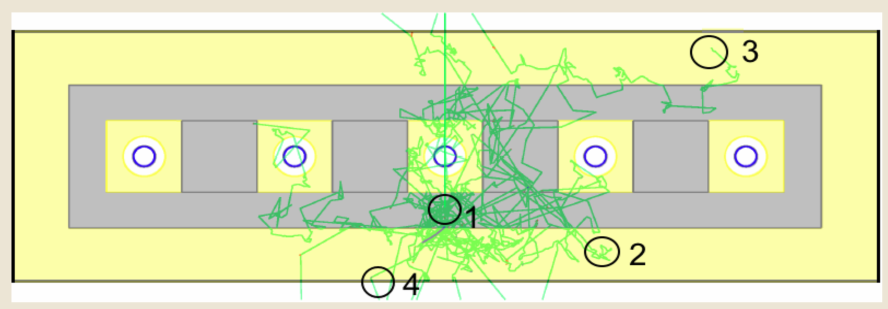
6. From standard to neutron monitor 30nm20.



A standard 6nm64 detector (left panel) and a 30nm2020 supermonitor module (right panel).

7. Neutron Supermonitor 30nm20.





Estimations of Counter Sensitivity:
S=¼ π n_0 P σ d^2 L, where
d×*L* – diameter and length
σ(*E*) [*barn*] – absorption cross section *n*
n_0 [cm^{-3}] – particle density
P [атм] – gas pressure in the meter

The efficiency of the reformatted neutron monitor, obtained with the help of the GEANT4 package. It can be seen that direct calculations fully confirm the estimate for the reformatted neutron monitor based on 5 cm helium counters LND253124, according to which the efficiency of such a detector is more than two times higher than CH01-2 meters with a diameter of 3 cm.

8. CONCLUSIONS.
With continuous monitoring of cosmic radiation in the waters of the Arctic Ocean along the route of the North Pole drifting station, new opportunities are opening up.

1) Due to the departure of the magnetic pole to the central part of the Arctic Ocean, the Thule station loses its position as the best detector for research on the north - south anisotropy, Barentsburg - practically does not change them. On the contrary, most of the observation time on the North Pole platform will be very favorable for such studies.
2) In the process of moving a floating platform when registering a specific event, we may be at the best point or at the worst point, but in any case it will be a unique region for conducting such studies.
3) Estimates and GEANT modeling processes in the combined detector of the muon telescope - the neutron supermonitor show that as a result of the reformatting of the neutron supermonitor and the use of the most sensitive neutron counters, the efficiency of the neutron monitor can be more than doubled, i.e. to achieve statistical accuracy of two standard sections of the neutron monitor.