Forecasting of Radiation and Geomagnetic Storms by networks of particle detectors (FORGES-2008)

Daily Variations of Cosmic Ray Flux at Minimum of Solar Activity

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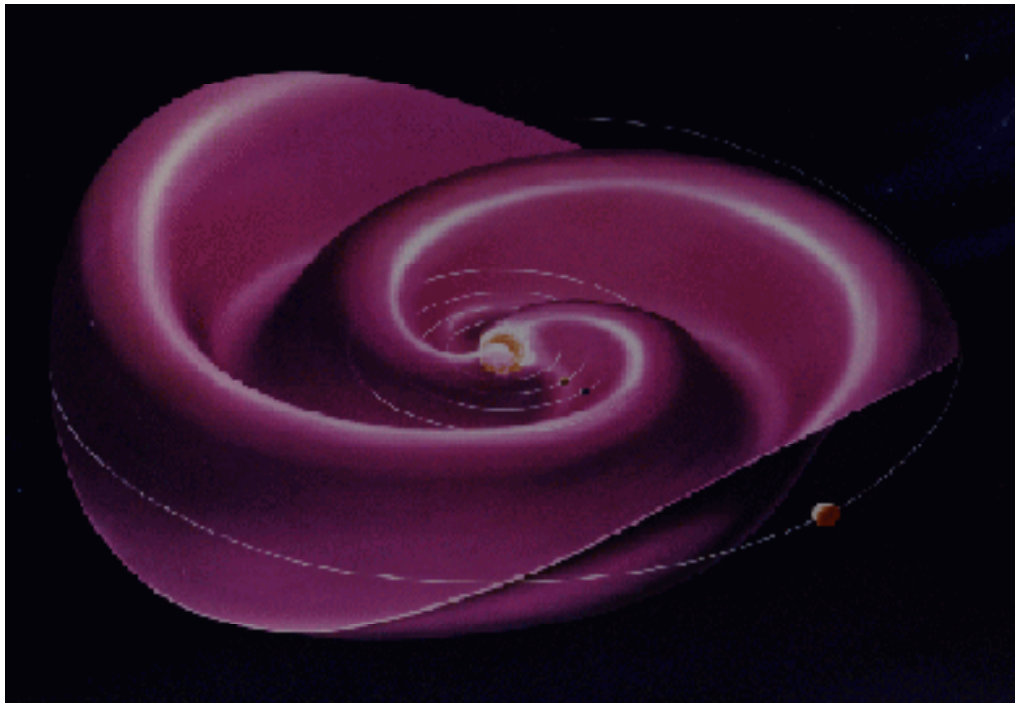
Why does daily variation of cosmic rays exist ?

- Because of rotation of the Sun, Interplanetary Magnetic Field has a form of Parker Spiral.

A three-dimensional form of the Parker spiral that results from the influence of the Sun's rotating magnetic field on the plasma in the interplanetary medium



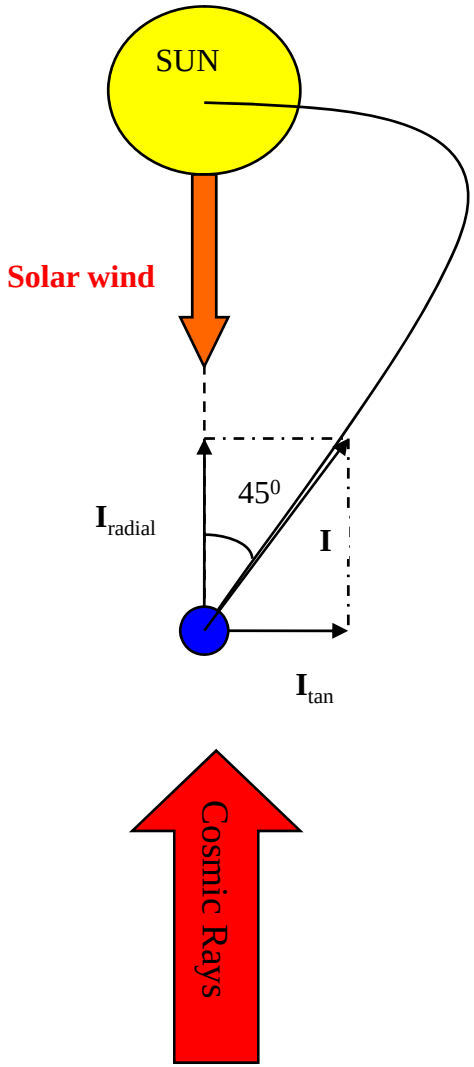
Intensity of cosmic rays in Solar system results from two processes

1. Convective outflow of galactic cosmic rays due to scattering on solar wind discontinuities
2. Diffusion of cosmic rays into Solar system

Why does daily variation of cosmic rays exist ?

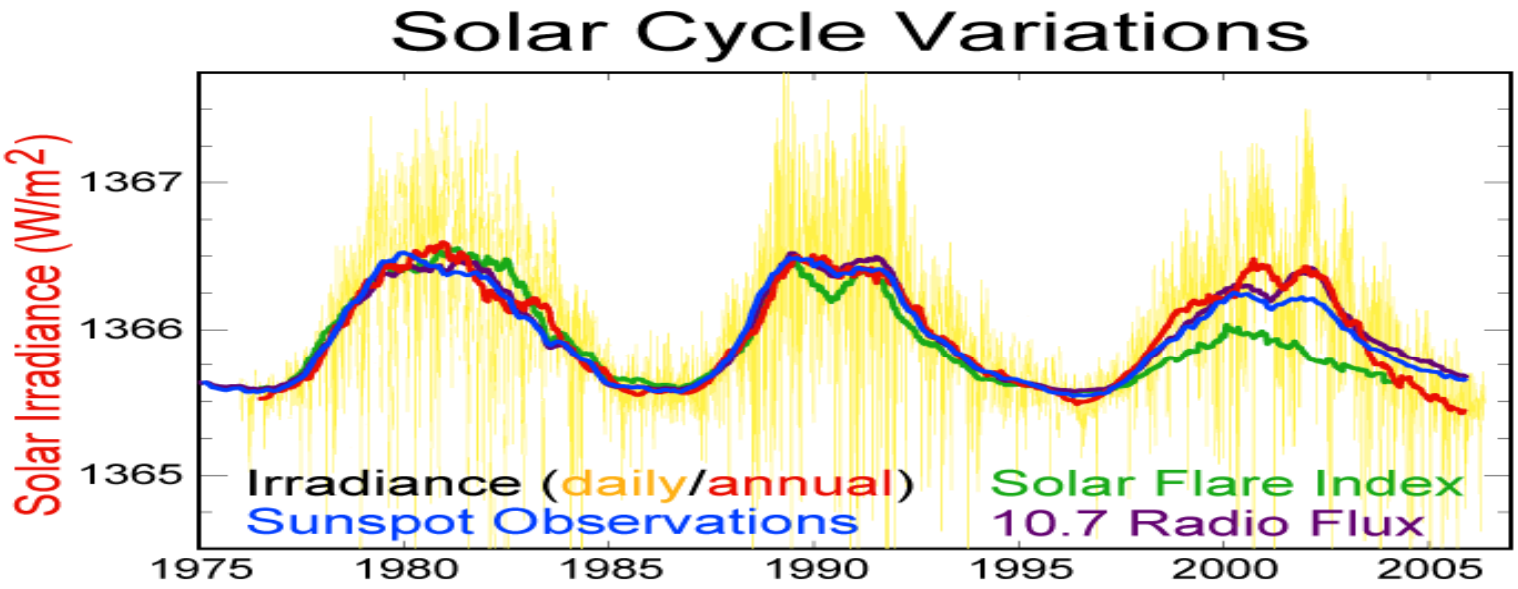
Daily variations understood to result from a combination of inward diffusion along the spiral interplanetary magnetic field and outward convection by the solar wind.

If we decompose cosmic ray flux into radial and tangential components, radial flux of galactic cosmic rays will be compensated by solar wind convective outflow.
Tangential component, due to Earth's rotation, causes variation with maximum at 18:00 local time.

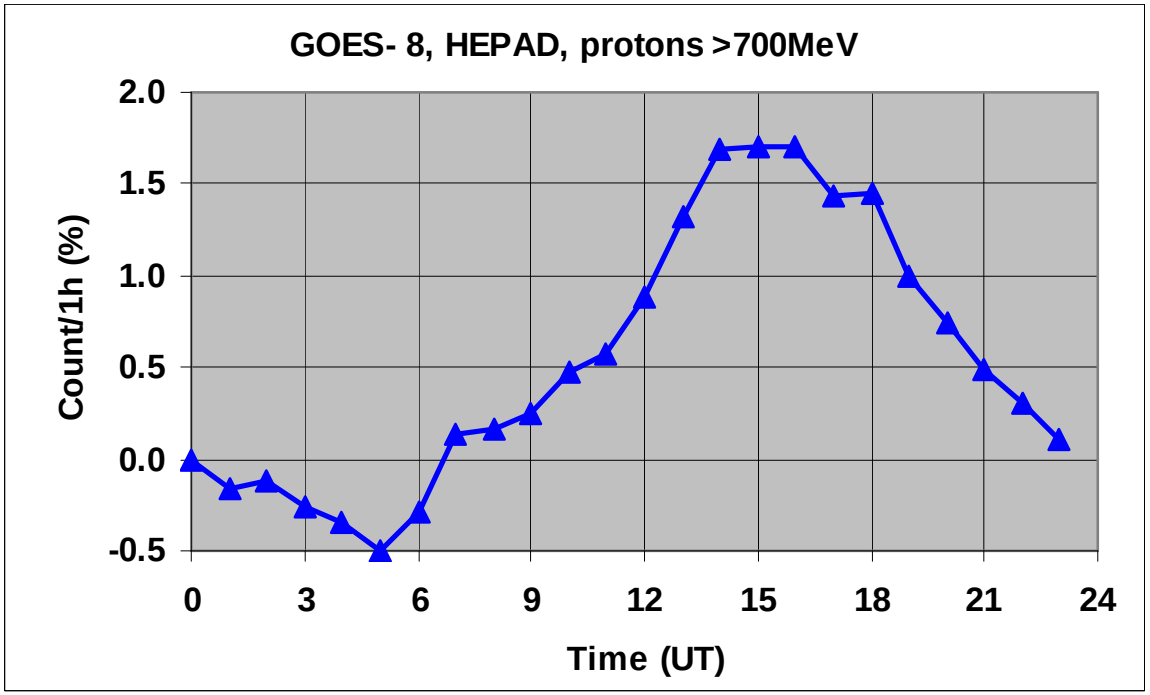


Why it’s important to investigate daily variations in the minimum of solar activity cycle?

- In the minimum of solar activity cycle interplanetary magnetic field is not disturbed and all of variations caused not by solar activity. Investigation of daily changes during minimum of solar activity let us to study their dependence on solar activity.



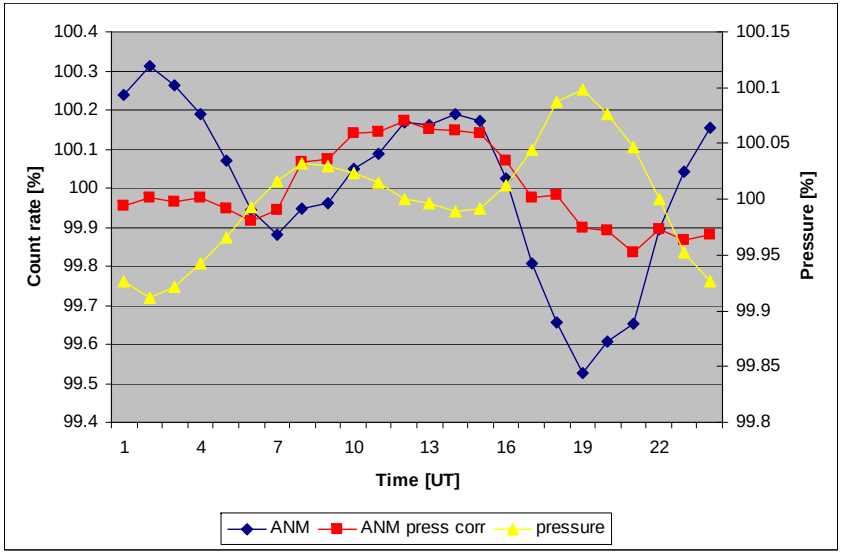
Daily variation of protons > 700MeV registered by GOES-8

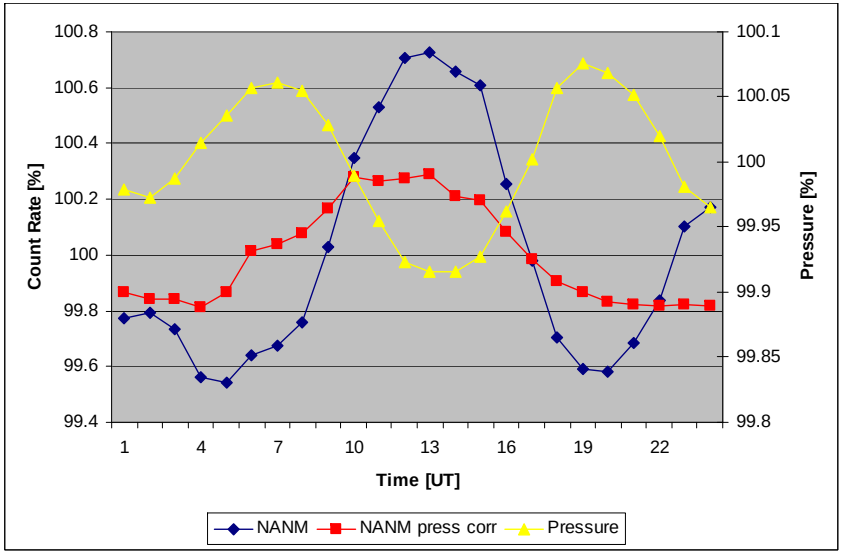


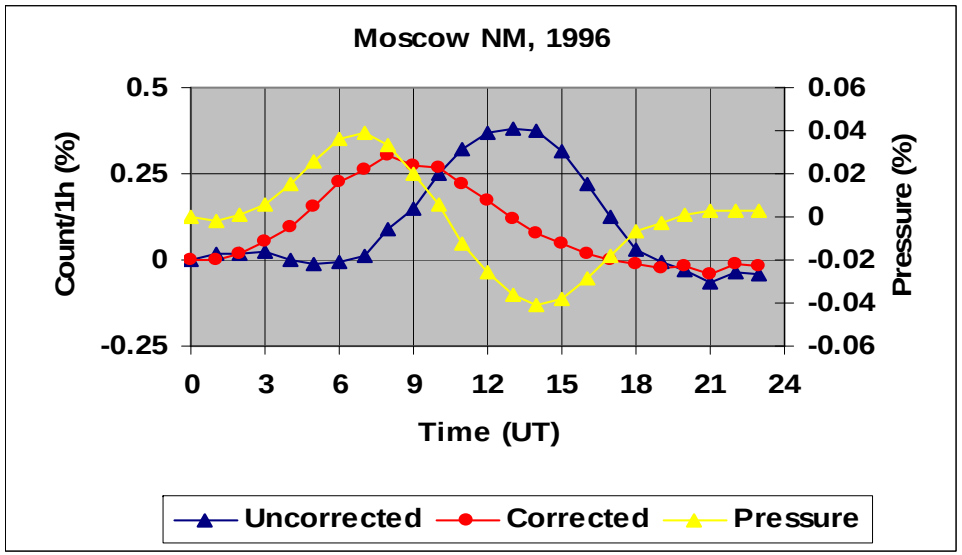
What we expect?

- Previous studies have found that maximum of daily changes should be at 18:00 local time, but due to bending from Earth's magnetic field, maximum is 1-4 hours earlier.
- Lower energy particles are more influenced by IMF. So changes will be bigger for lower energy cosmic rays. It's also expected that daily changes of different populations of secondary particles will be different. Besides, changes can depend on the location height of detector.

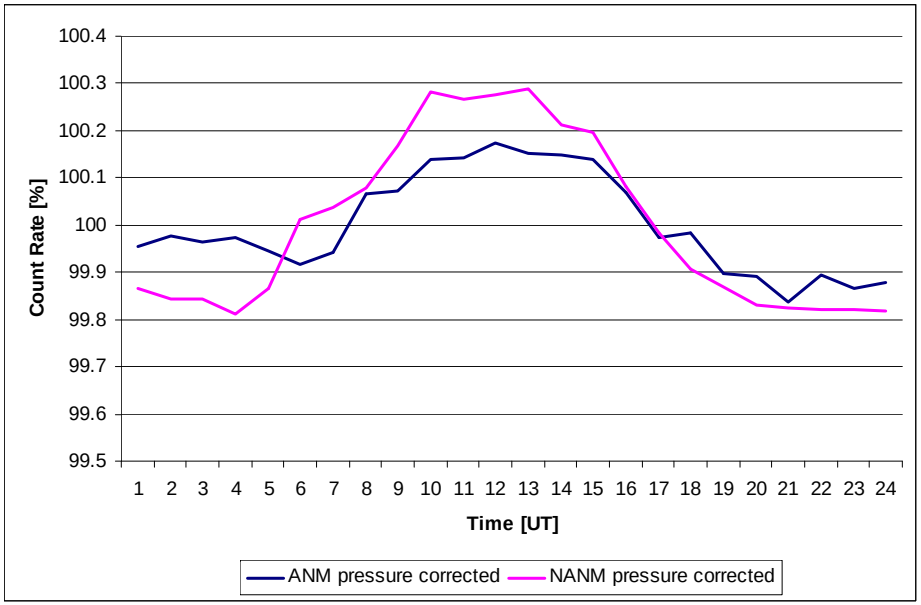
Daily variations according to Aragats, Nor Amberd and Moscow neutron monitors' data



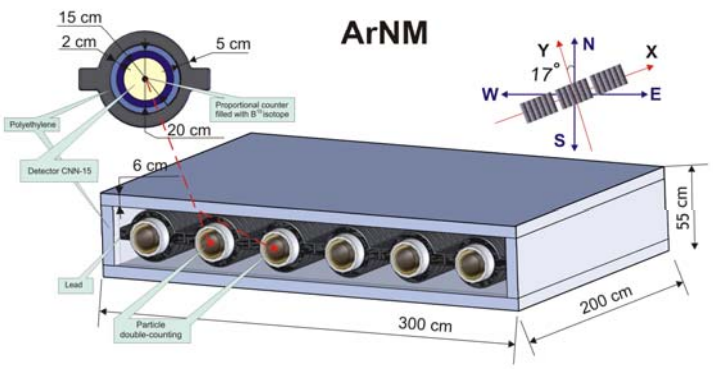


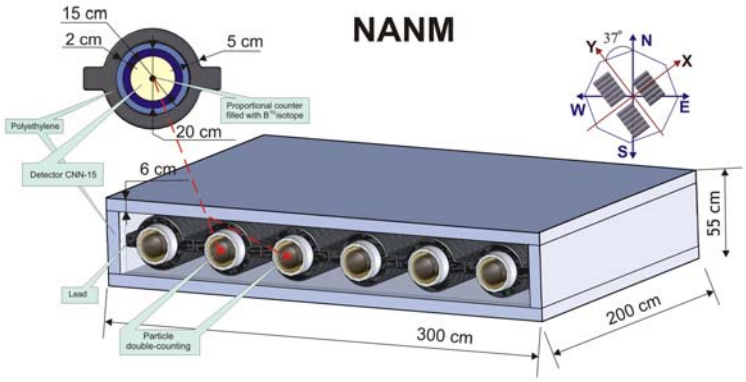


Daily variations according to Aragats and Nor Amberd neutron monitors' data

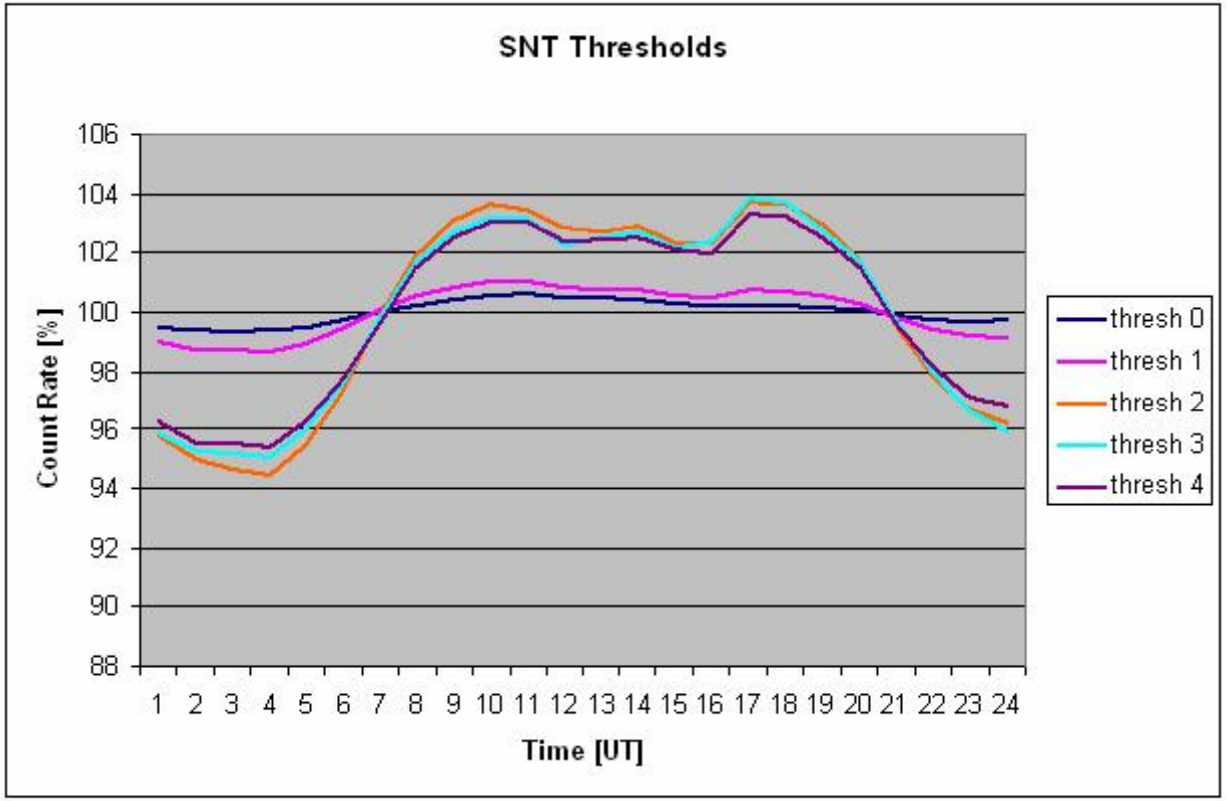


ANM changes are about 0.17% and maximum located at 12.00 UT, i.e.17:00-18:00 local time.
NANM (Nor Amberd Neutron Monitor) located at lower altitude (2000 m) than ANM (3200 m). NANM changes are approximately 0.28 % and bigger comparing with ANM changes. We should confirm this result with improved statistics.





Daily variations according to Aragats Solar Neutron Telescope data



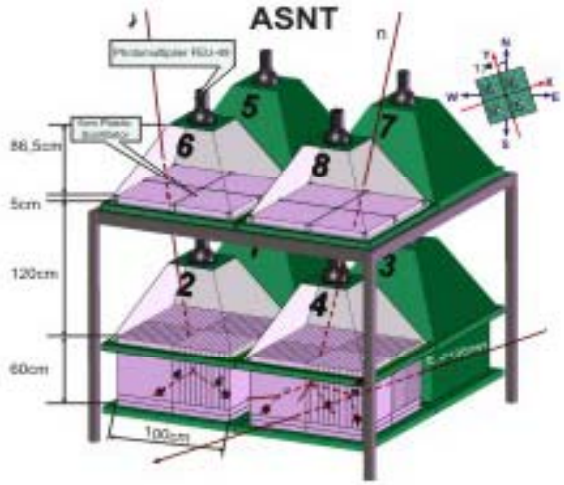
Thresh 0 – 7MeV

Thresh 1 – 85MeV

Thresh 2 – 170MeV

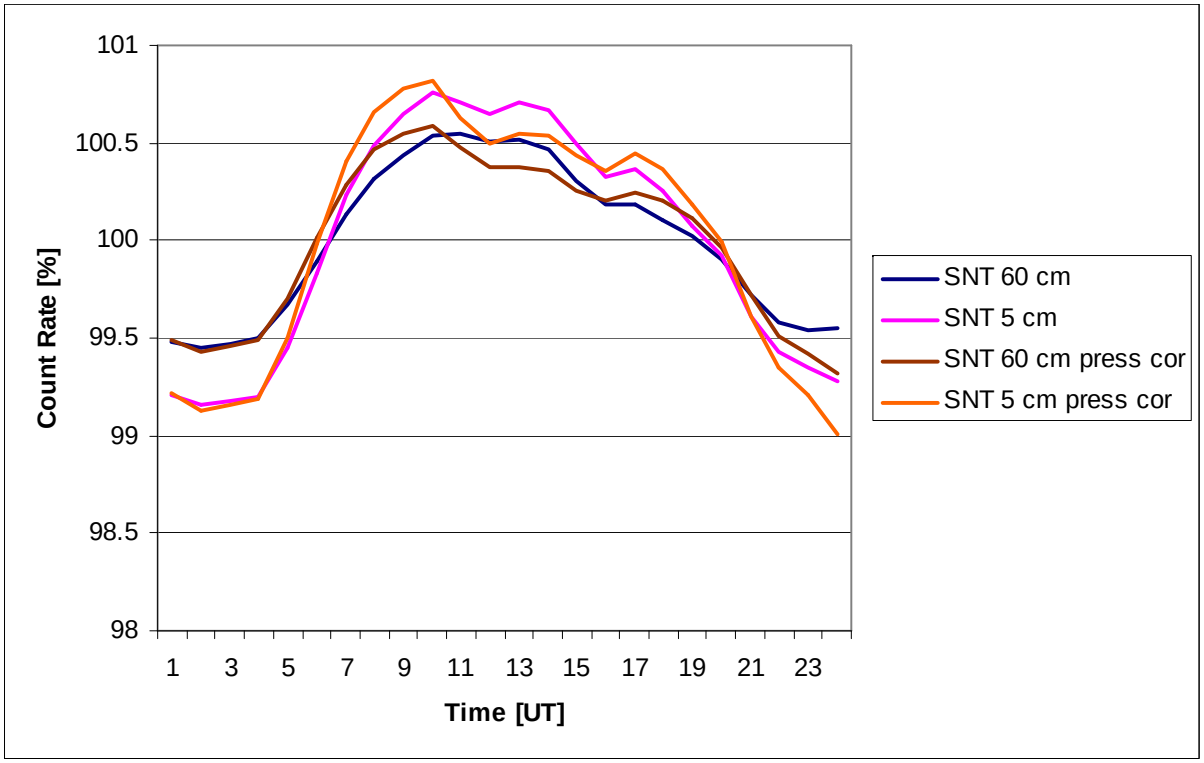
Thresh 3 – 255MeV

Thresh 4 – 380MeV



Daily variations for high energy thresholds are about 10 times bigger!

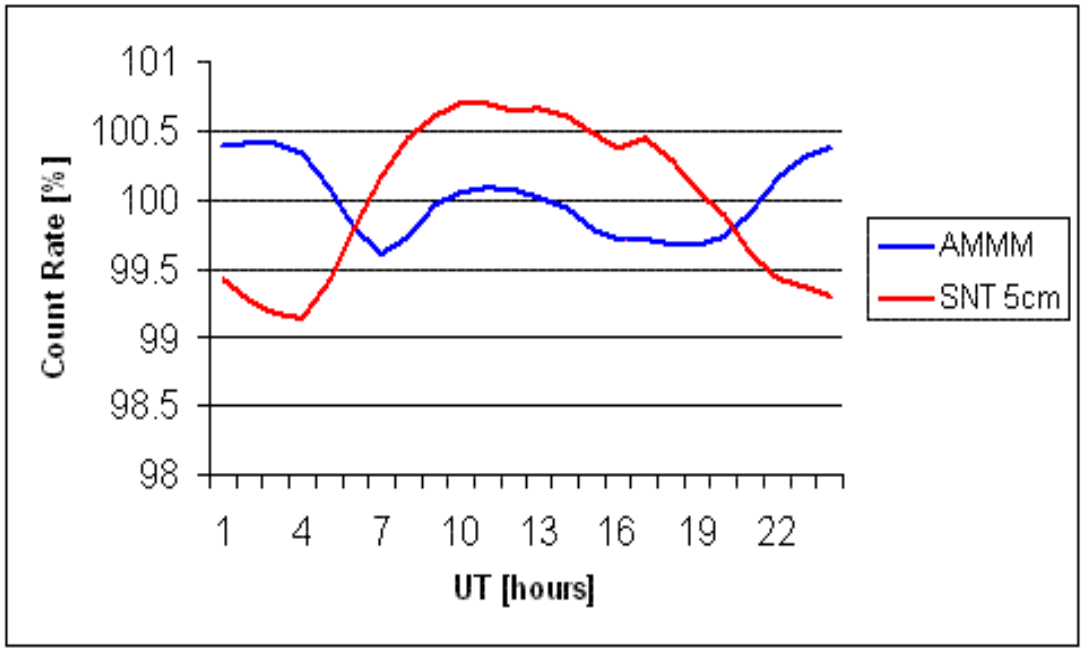
Daily variations according to Aragats Solar Neutron Telescope data



SNT 5cm	04:00, -0.86%	11:00, 0.7%
SNT 60 cm	04:00, -0.53%	11:00, 0.53%

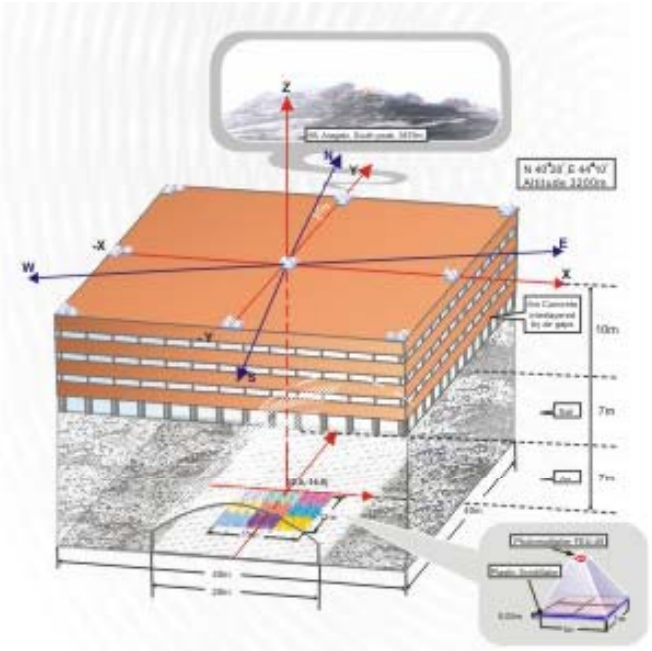
In investigation of muon flux variations barometric and temperature effects have to be taken into account .
Muon flux is less sensitive to pressure changes than neutron flux.

Daily variations according to Aragats multidirectional muon monitor. Comparison with daily variations of low energy particles

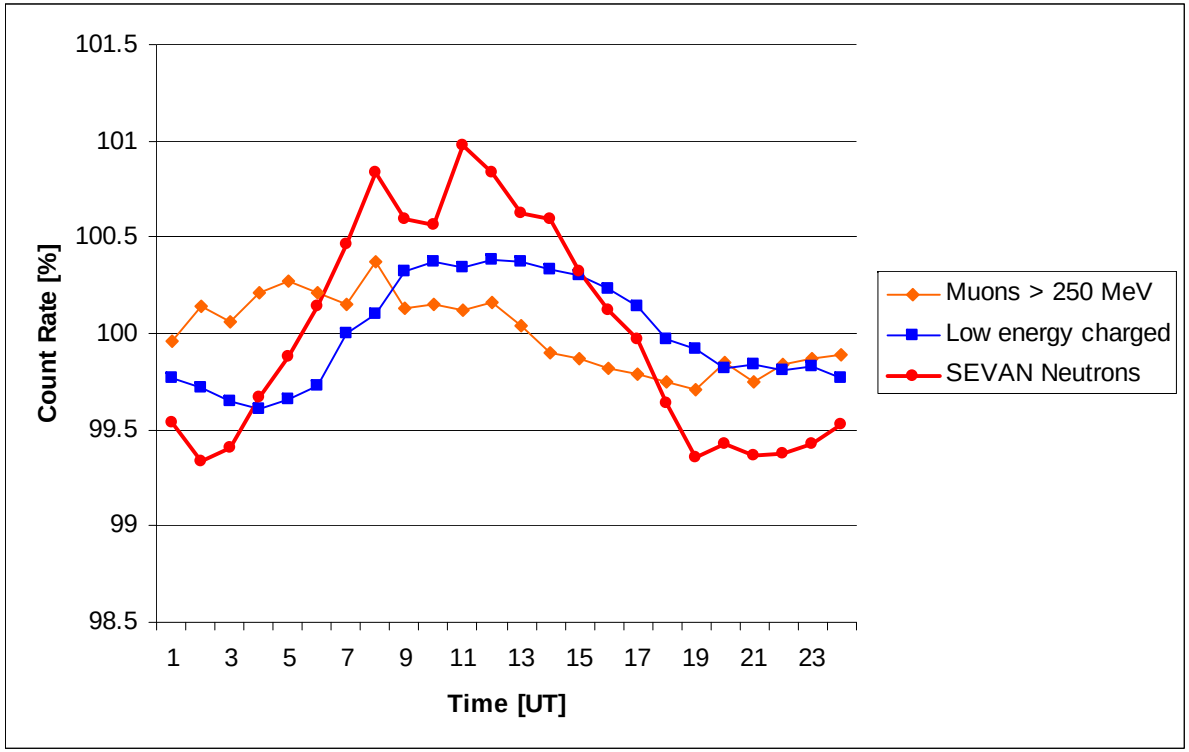


AMMM	07:00, -0.39%	01:00, 0.41% 12:00, 0.15%

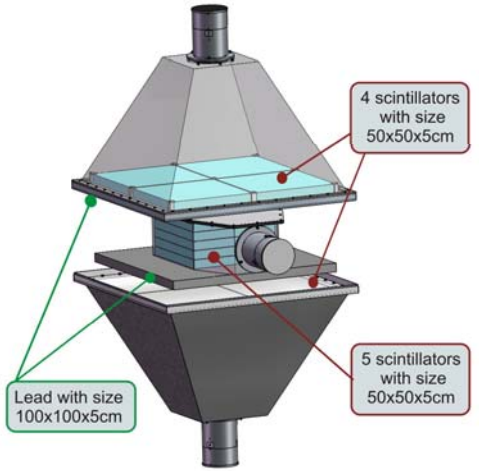
The pattern of daily variations of 5 GeV muons is more complicated, than for neutrons.
Existence of 2 minimums and maximum in between needs additional analysis for relevant interpretation.



Daily variations according to SEVAN detector data



Different coincidences of SEVAN detector correspond to different species of secondary cosmic rays



SEVAN high energy muons	18:00, -0.25%	07:00, 0.25%
SEVAN low energy particles	04:00, -0.4%	11:00, 0.38%
SEVAN neutrons	02:00, 0.7% 21:00, 0.6%	11:00, 0.79%

Results

Monitor	Amplitude and time of minimum (s)	Amplitude and time of maximum(s)
AMMM	07:00, -0.39%	01:00, 0.41% 12:00, 0.15%
SNT 5cm	04:00, -0.86%	11:00, 0.7%
SNT 60 cm	04:00, -0.53%	11:00, 0.53%
ANM	07:00, -0.12% 19:00, -0.48%	14:00, 0.19%
ANM pressure corrected		12:00, 0.17%
NANM	05:00, -0.46% 20:00, -0.42%	12:00, 0.7%
NANM pressure corrected		11:00, 0.28%
SEVAN high energy muons	18:00, -0.25%	07:00, 0.25%
SEVAN low energy particles	04:00, -0.4%	11:00, 0.38%
SEVAN neutrons	02:00, 0.7% 21:00, 0.6%	11:00, 0.79%

Future work

- provide more statistics
- perform pressure and temperature corrections for muon data
- perform Fourier analysis and separate diurnal, semi-diurnal and tri-diurnal variations

Thank you!