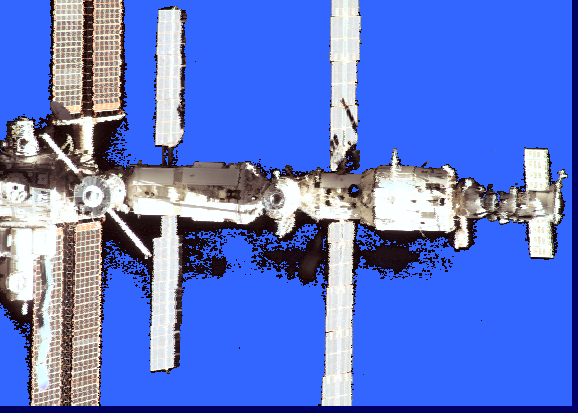

ISS ATTITUDE INFLUENCE ON THE DOSE RATE MEASURED WITH LIULIN-5 INSTRUMENT

I. Chernykh, V. Petrov, V. Shurshakov, J. Semkova, R. Koleva, St. Maltchev, N. Bankov, V. Mitrikas, V. Benghin, S. Drobyshev, V. Lyagushin, Yu. Roslyakov

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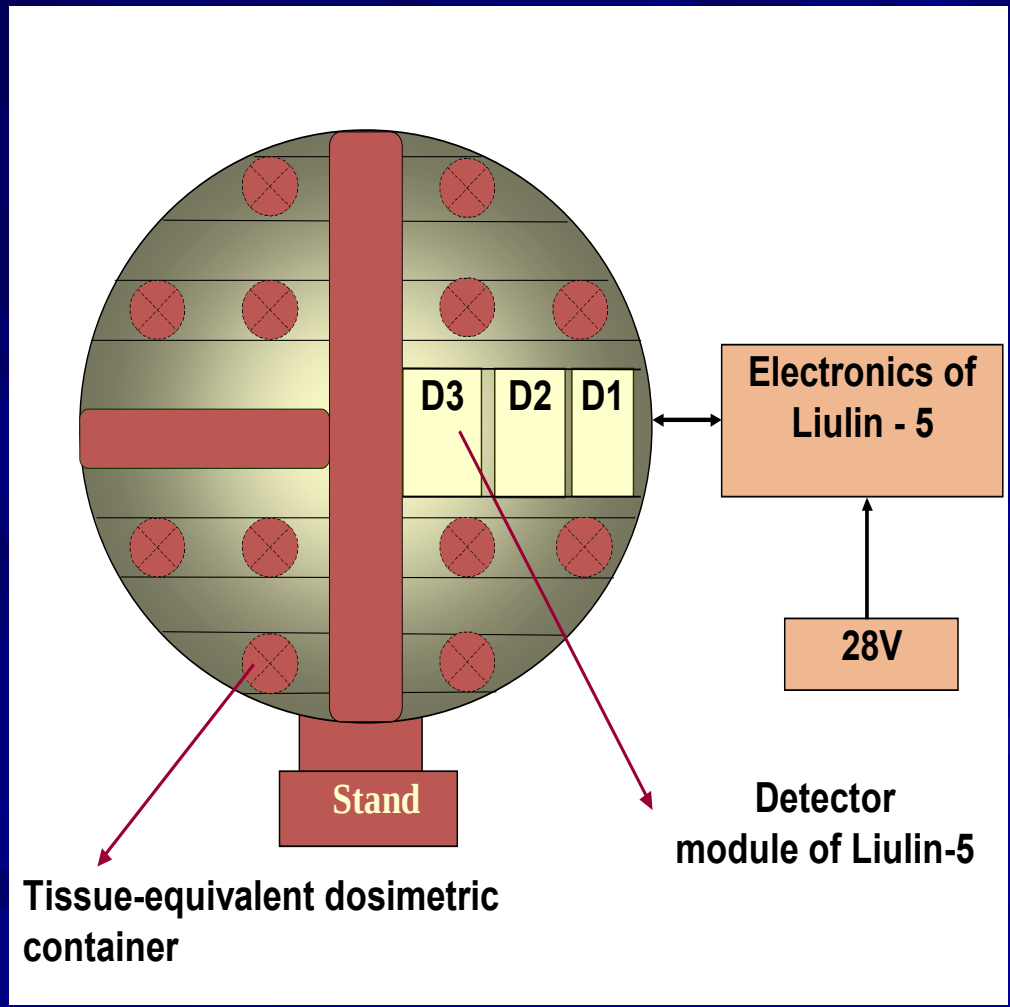
INTRODUCTION

- **Liulin-5 experiment is a part of the international project MATROSHKA-R. The aim of Liulin-5 experiment is long term investigation of the depth - dose distribution inside the spherical tissue-equivalent phantom.**
- **Experiment Liulin-5 for investigation of the radiation environment dynamics within the spherical tissue-equivalent phantom on ISS started in June 2007 on RS of ISS. Since then it runs permanently.**

The description of device "Liulin-5" and the spherical tissue-equivalent phantom have already been repeatedly presented in articles and reports, in particular, on recent, 37th scientific meeting COSPAR (July 13-20, 2008, J.Semkova et al.)

Block - diagram of Liulin - 5 connections in the phantom



External view of Liulin-5

Electronic Block

Phantom

Detector Block

Liulin-5 in the spherical phantom

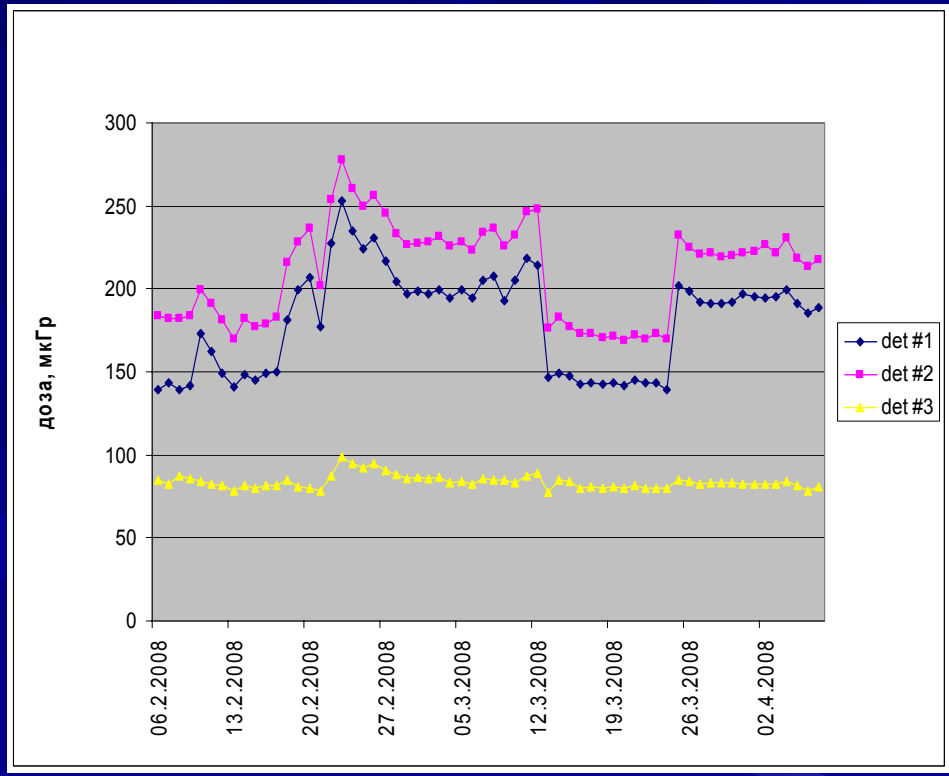
Two units: a detector block in the phantom channel and an electronic block outside it.

Parameters measured

- Absorbed dose rate in the range 0.04 $x10^{-6}$ Gy/h - 0.04 Gy/h;
- Intensity of the particle flux in the range 0 - $4x10^{2}$. particle/(cm^{2}.sec);
- Energy deposition spectra

Daily doses for the period 06.02 - 06.04.2008

- The daily dose values decreased during the period **from March 12 to March 26, 2008**
- ISS orientation change during this period



The effect observed caused the following plan of our study

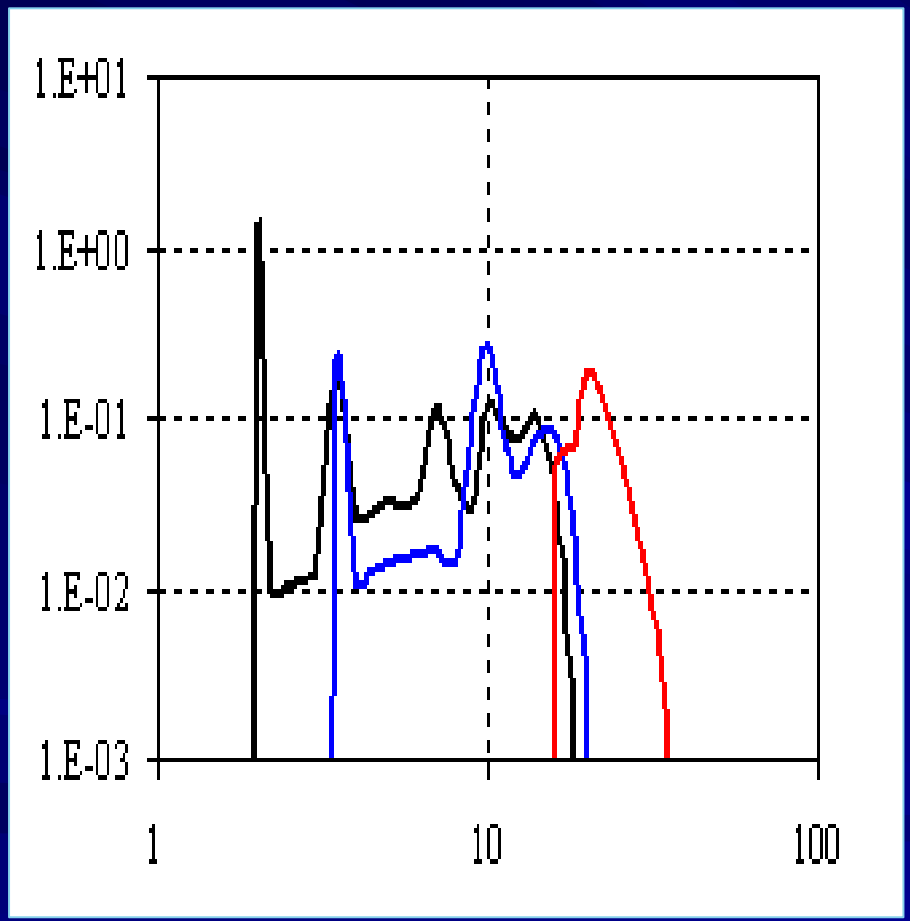
- To estimate the detector shielding for the Liulin-5 detector unit located inside the spherical phantom
- To consider Liulin-5 attitude to the given coordinate system during Matroshka-R experiment
- To examine interrelation between attitude of the Liulin-5 detector block axis and the dose rate measured when by SAA passage

Llulin -5 in the Spherical Phantom on ISS

Detector block

Liulin-5 in the Phantom on PIERS module of ISS –activated 28 June 2007.

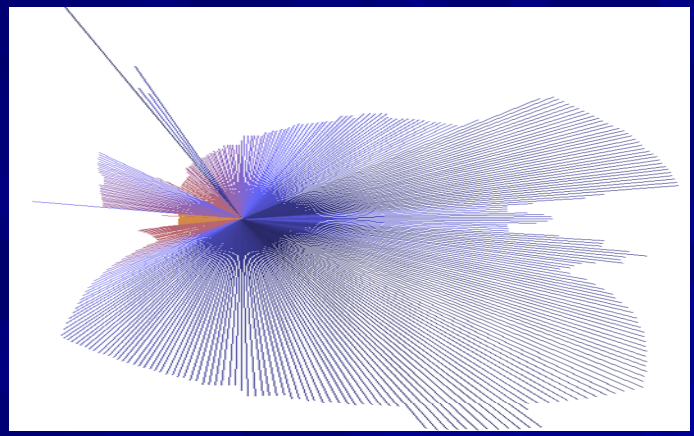
Shielding functions for each detector of the detection block



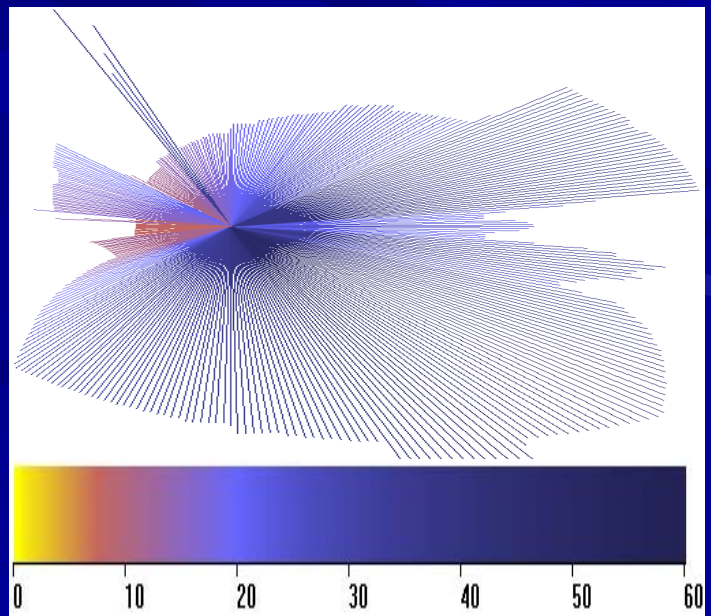
- 1 detector – black
- 2 detector - blue
- 3 detector – red
- Axes X –thickness (g/sm^2)
- Axes Y -**density of probability 1 /** (g/sm^2)

Angular shield distribution in horizontal section

- Direction to the left corresponds to the axis of the detector block
- Shield value is much lower close to the detector block axis than in other directions
- Shield, g/cm2

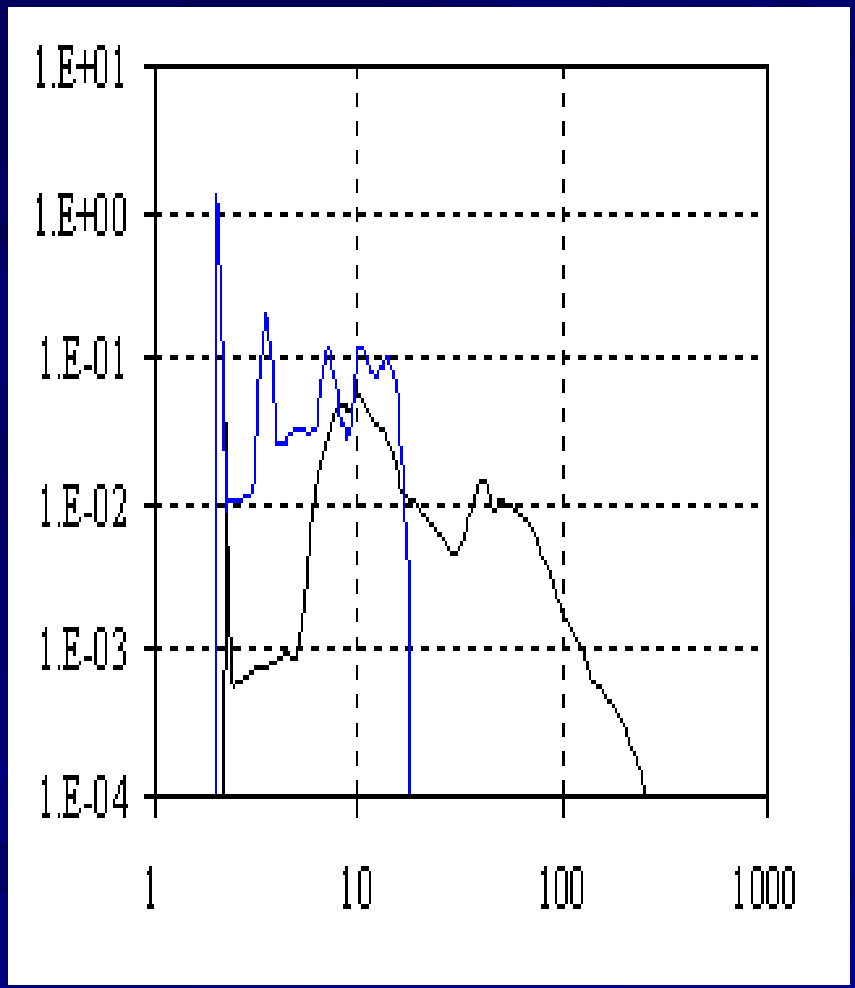


1 det



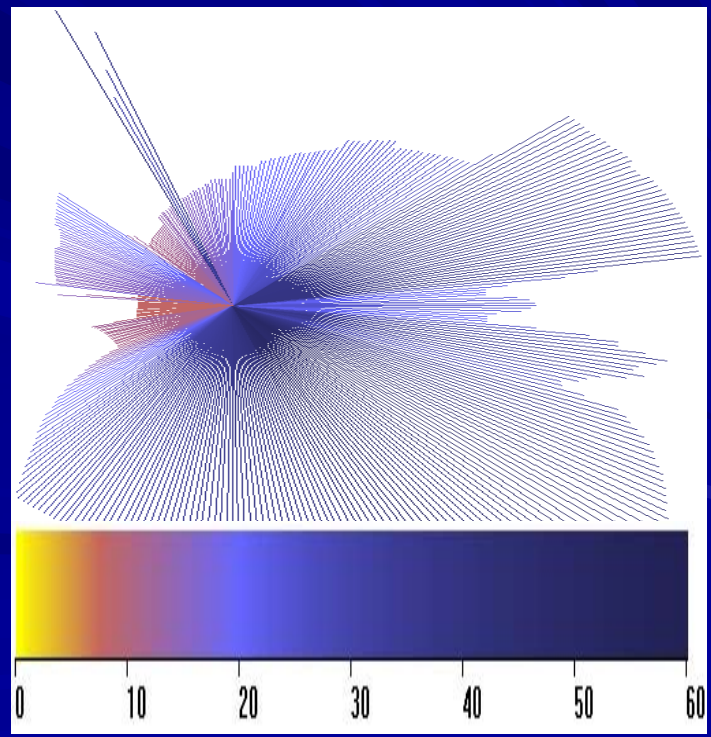
2 det

Shielding functions

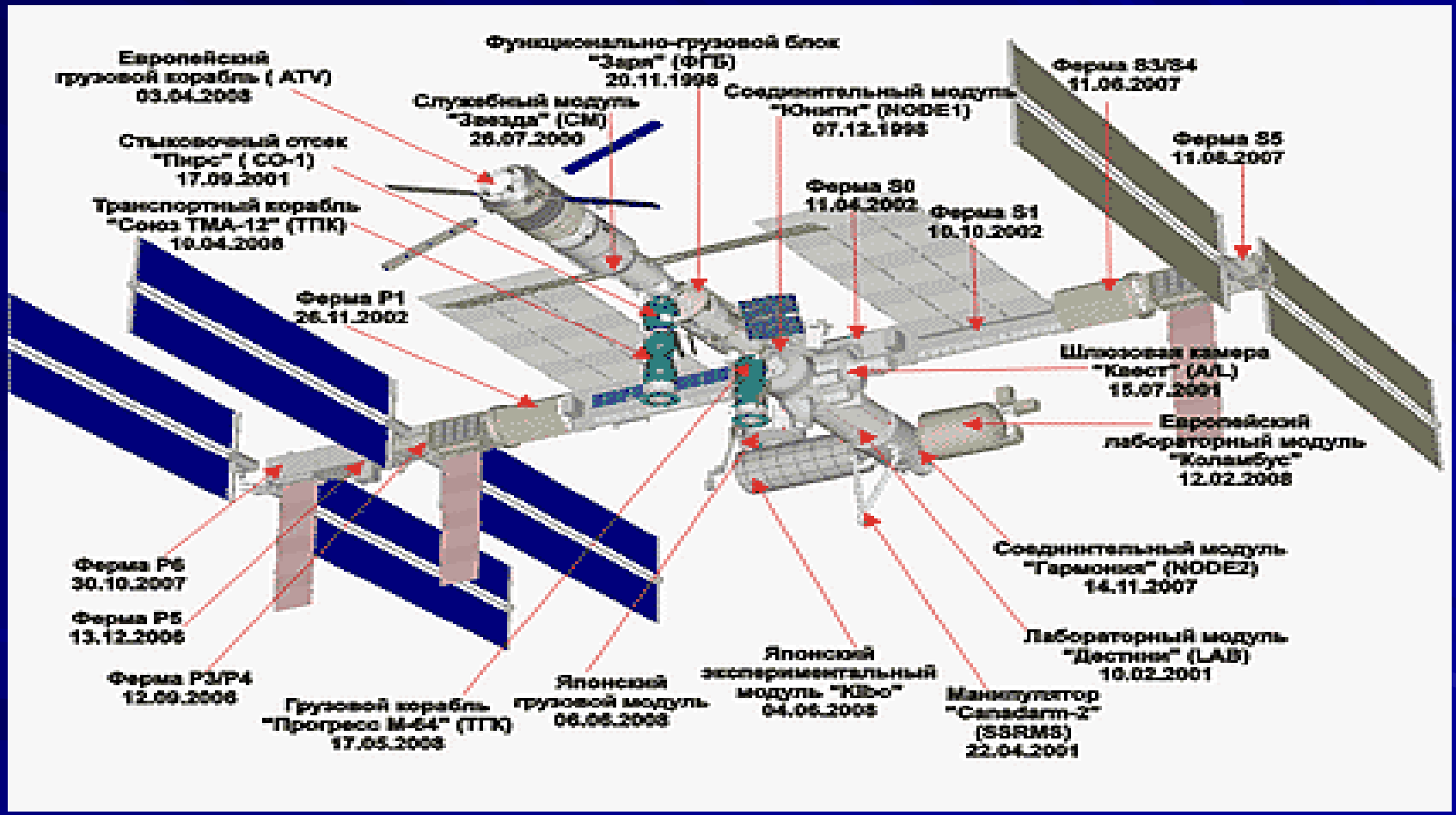


- Shielding functions of the first detector for cones with half-angle of 20 degrees (blue) relative to the detectors' axis and also for all 4π vectors (black)
- In these directions effective shielding of the detector is essentially lower.
- Axes X –thickness (g/sm^2)
- Axes Y -density of probability **1 /** (g/sm^2

- It is important to determine how is this low-shielded zone turned relative to the direction of the maximum high-energy proton flux (**South-Atlantic anomaly zone**).

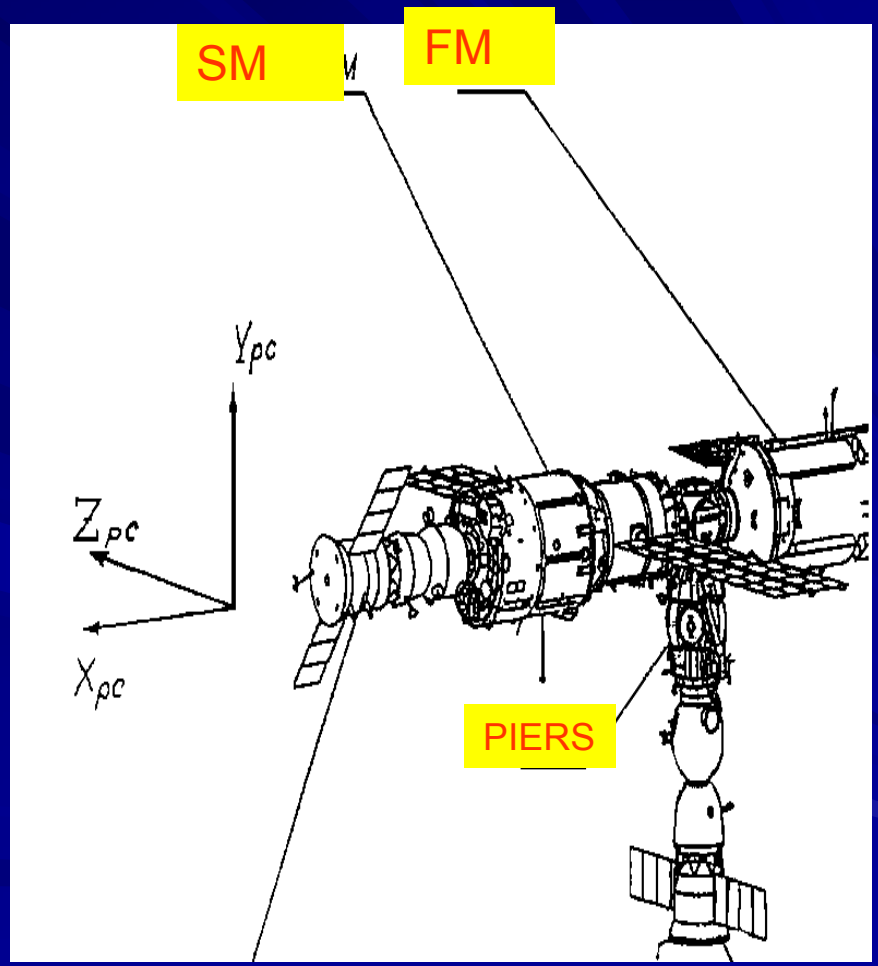


Position of the PIERS module at the ISS



Axes of the related coordinate system

- The axis of Liulin-5 detector block lies in plane XOZ of the related coordinate system and it is directed at an angle of 45 degrees between “x” and “z” axes.



- Considering the influence of the SAA radiation field anisotropy on dose rate value on board the ISS it is necessary to take into account a real location of the station in the SAA zone (it's geographical coordinates) and it's attitude relative to the radiation field.

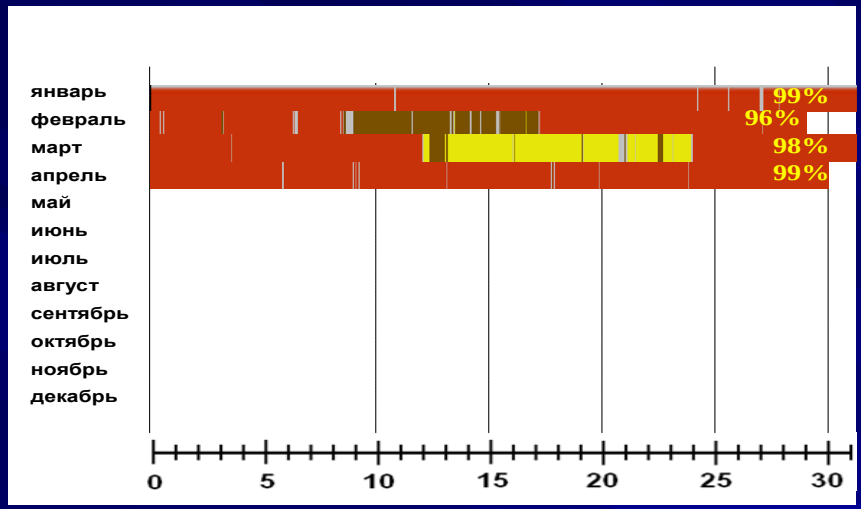
- To calculate the attitude we used the data of the Space Flight Control Center- the values of angles determining the ISS attitude relative to the orbital coordinate system. Orbital coordinate system is connected with the moving of the ISS along the Earth orbit:

- X-axis is directed along the spaceship velocity vector projection onto the local horizon plane;
- Y-axis is directed from the Earth center to the spaceship position along the Earth radius-vector (as in topocentric system);
- Z-axis forms rights-hand system with other axes .

Analysis of the ISS attitude data obtained from the Space Flight Control Center shows that from June,2007 to April, 2008 (the period of performing measurements with **Liulin-5** device) the ISS had two types of attitude:

- the first type – the salon of small diameter of SM (Zvezda) module looks by forward in the direction of the ISS velocity vector,
- the second type – it looks backward

The results of ISS attitude data processing from January to April, 2008



- This change of the ISS attitude resulted into the change of the **Liulin-5** detection block axis vector relative to the direction of maximum proton flux in the SAA zone

- Red colour - corresponds to the first type of attitude
- Yellow colour – to the second type.
- Brown colour - shows the periods, when the long axis of Zvezda module is deviated from the ISS velocity vector more than at 20 degrees.
- Grey colour - indicates such periods when ISS attitude couldn't be defined properly on basic of the available data.

Estimation of the proton flux angular distribution in SAA

- The vector of the Liulin-5 detector block axis and the angular distribution of proton flux was combine in the same coordinate system (topocentric).
- **Calculations of proton flux angular distributions have made using the relations pointed at the paper /1/ .**
- **To calculate geomagnetic vector and L-B coordinates**

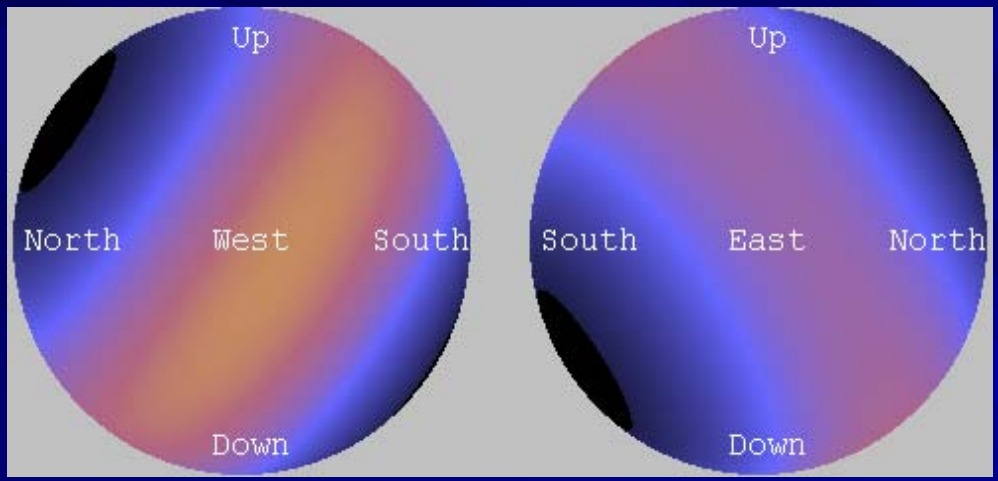
we used the program /2/ developed at the Moscow State University on basis of geomagnetic field model IGRF/DGRF /3/ developed at the NASA.

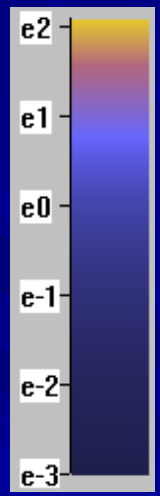
1..**Benghin V.V., Petrov V.M., Shurshakov V.A, Muratova I.A. Angular distributions of trapped protons in the SAA. Kosmitcheskiye issledovaniya (Space research), 1991, v.29, 6 (in Russian)**

2. http://alexeypetrov/narod/ru/Fortran/igrf.html/
3. http://modelweb/gsfs/nasa/gov/

Flux angular distribution for 50 MeV protons carried out for coordinates: longitude = -52,5º; latitude = -27,2º; altitude = 344,9 km. To the right of the distribution there is a colour scale showing the intensity value in units

$cm^{-2}\,s^{-1}\,MeV^{-1}sr^{-1}$

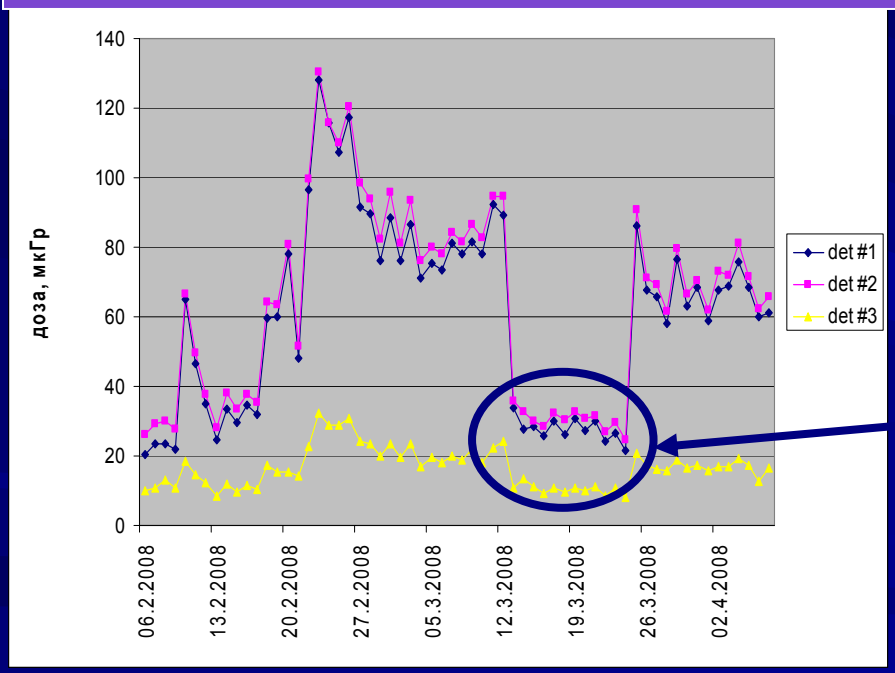




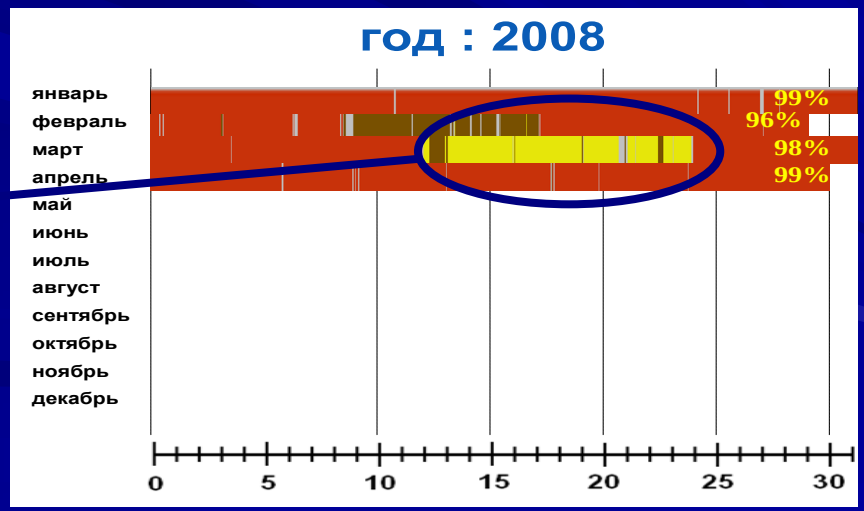
- **To show flux distribution in all directions we used a representation with two hemispheres. The left hemisphere is a view from the west and the right one – a view from the east.**

ERB contribution to a daily dose registered by the Liulin-5 detectors from February of 2008 till April of 2008

Daily dose – fasten measurement mode



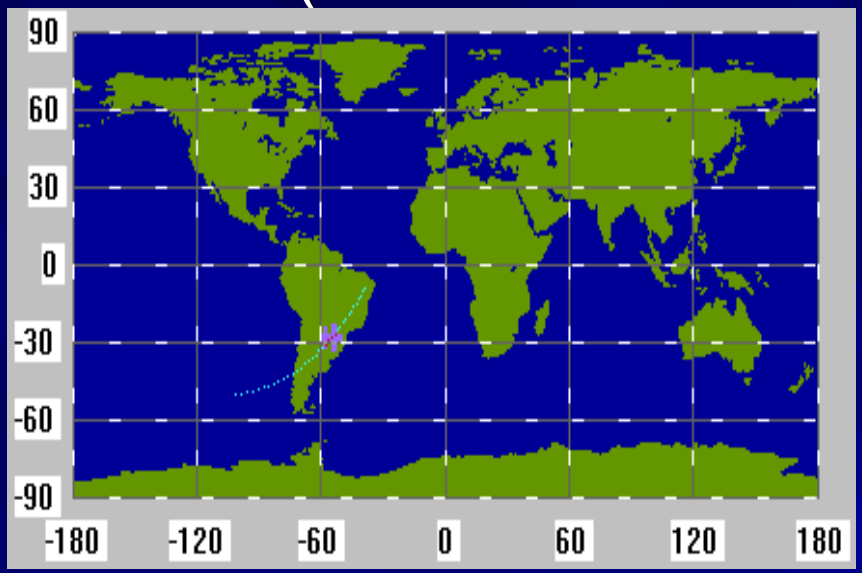
- Contribution of the GCR is fairly constant. All changes are caused by the ERB contribution.



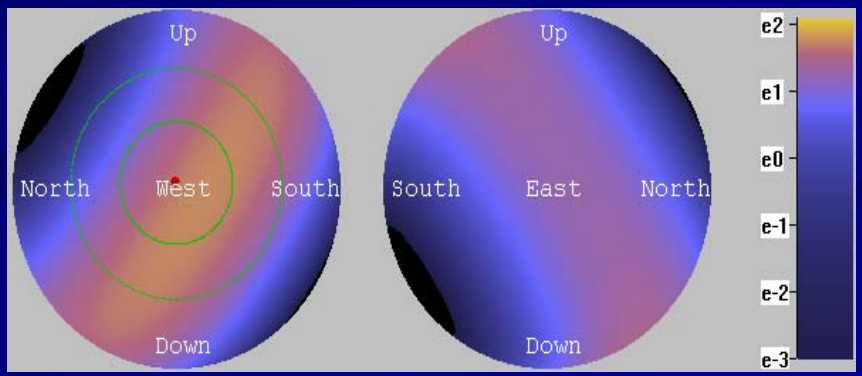
Interrelation between Liulin-5 detection block axis orientation and dose rate value during passing through the SAA zone

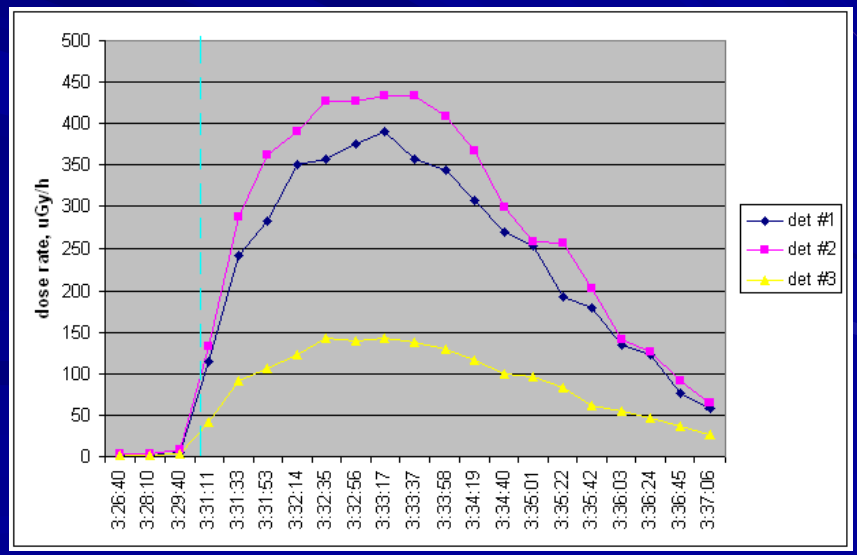
- Let's look at the attitude of the Liulin-5 detector block axis relative to the maximum proton flux direction in the SAA zone before and after drastic decreasing of the registered dose rate. For that let's view ISS passing through the SAA zone along close trajectories for ascending and descending orbit circuits. We have calculated the attitude of the Liulin-5 detector block axis for four characteristic cases of passing through the SAA zone. First two cases (one – for ascending orbital circuit, another – for descending circuit) are related to the period before decreasing of indicated values. Next two cases are related to the period after decreasing. Calculation results are presented in slides.

Passing through the SAA area March 6, 2008 at 03:31 on the ascending orbit circuit. The **Liulin-5** detection block axis (red point) is directed to the west (in the direction of maximum proton flux)



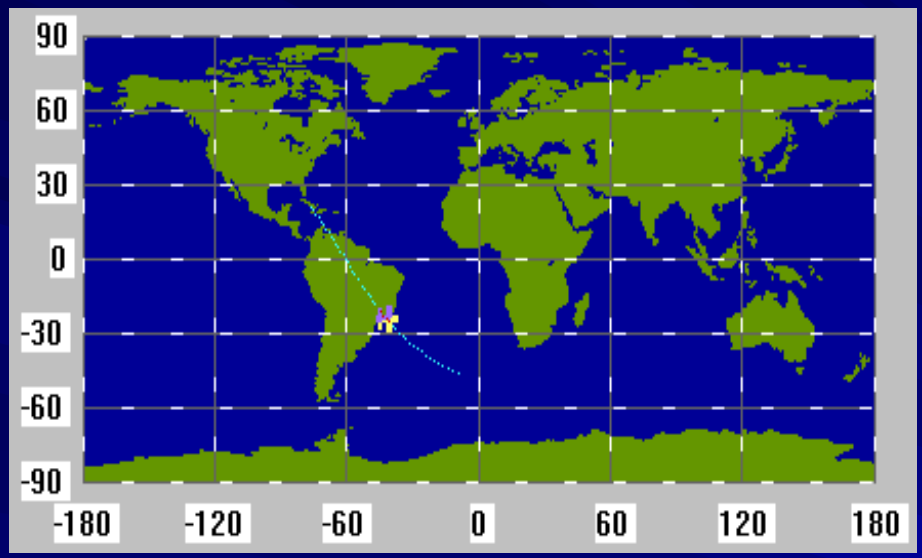
- a trajectory of the ISS and the point at which the attitude calculation has been performed
- the proton flux angular distribution in the form of two hemispheres, brighter colours correspond to greater flux.
- dose rate dynamics registered by the detectors during considered passing of the SAA area



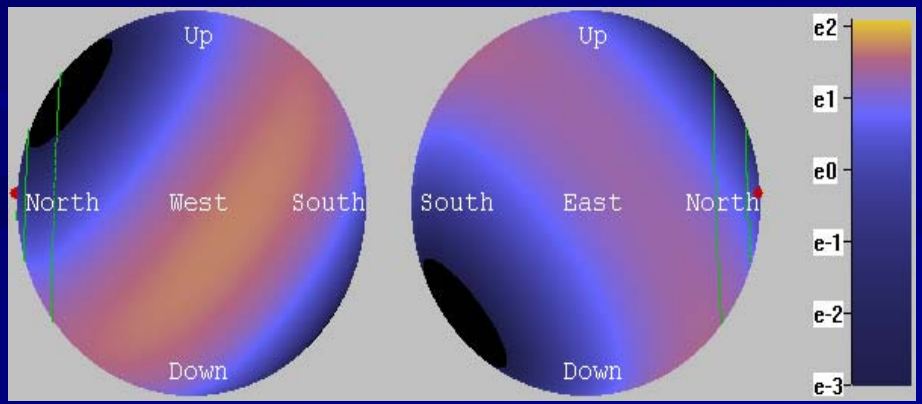


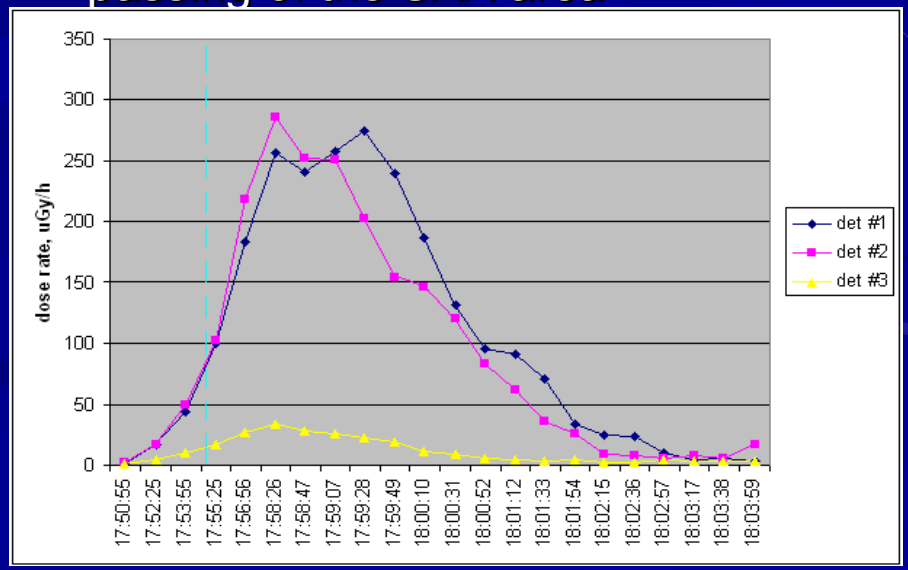
Passing through the SAA area March 5, 2008 at 17:55 on the descending orbit circuit.

The Liulin-5 detection block axis (red point) is directed to the north

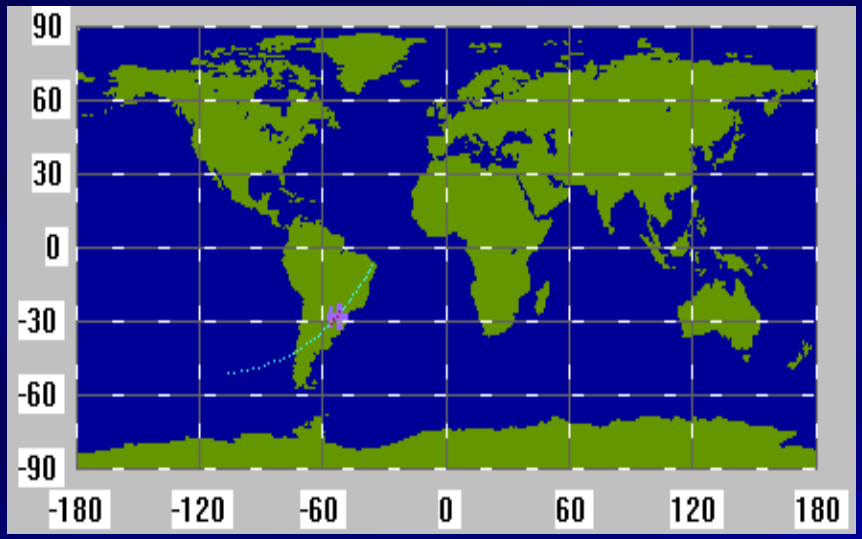


- a trajectory of the ISS and the point at which the attitude calculation has been performed
- the proton flux angular distribution in the form of two hemispheres brighter colours correspond to greater flux.
- dose rate dynamics registered by the detectors during considered passing of the SAA area

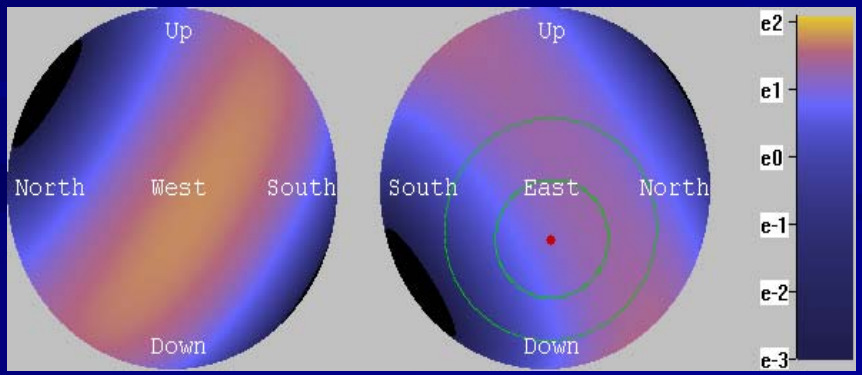


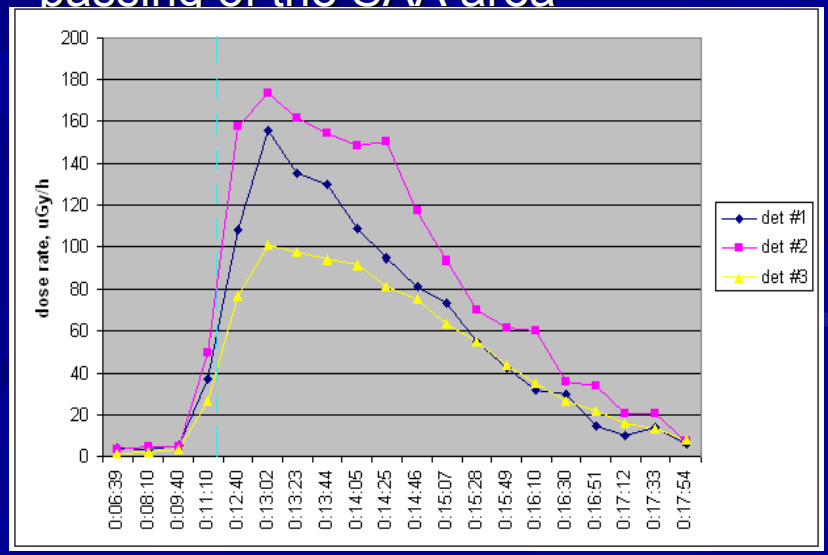


Passing through the SAA area March 14, 2008 at 00:12 on the ascending orbit circuit
The **Liulin-5** detection block axis (red point) is directed to the east

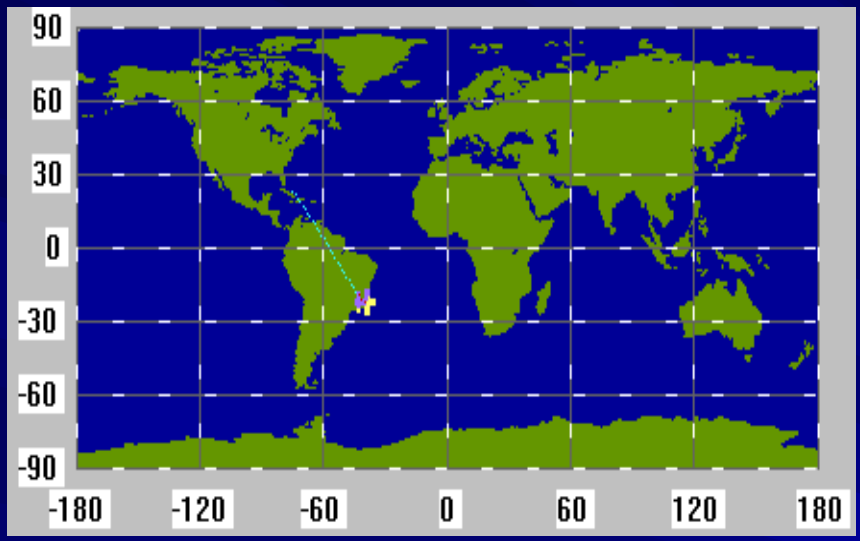


- a trajectory of the ISS and the point at which the attitude calculation has been performed
- the proton flux angular distribution in the form of two hemispheres, brighter colours correspond to greater flux. ,
- dose rate dynamics registered by the detectors during considered passing of the SAA area

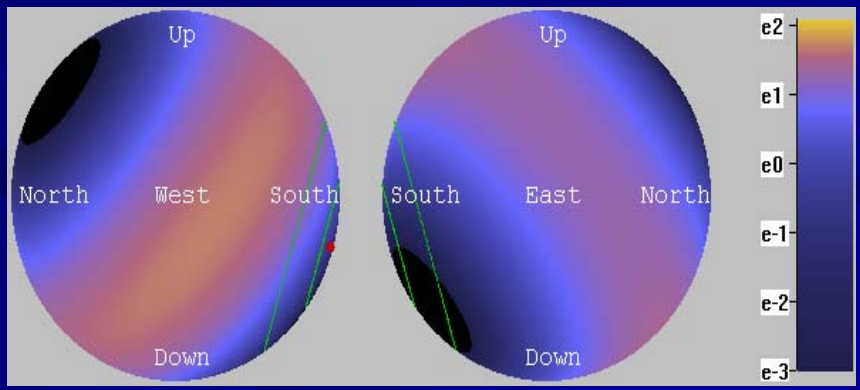


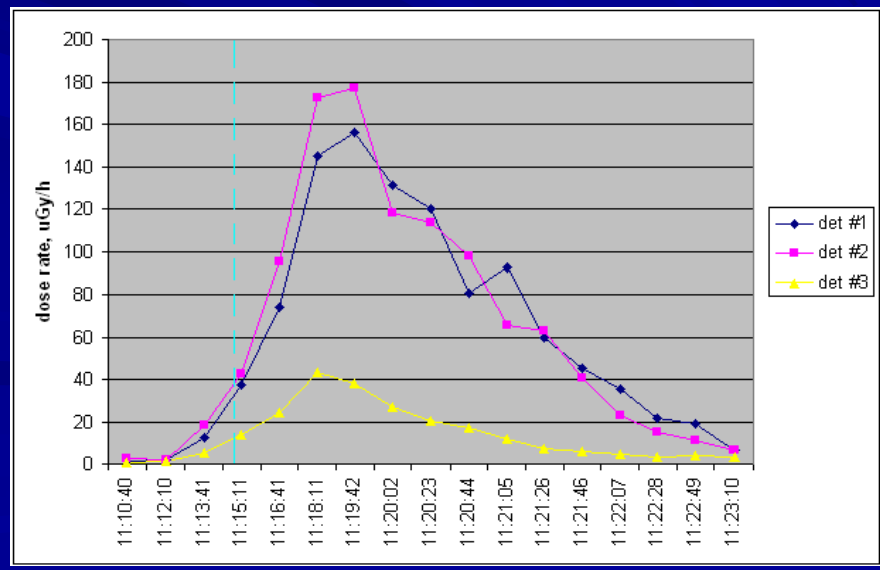


Passing through the SAA area March 21, 2008 at 11:15 on the descending orbit circuit. The **Liulin-5** detection block axis (red point) is directed to the south



- a trajectory of the ISS and the point at which the attitude calculation has been performed
- the proton flux angular distribution in the form of two hemispheres
- dose rate dynamics registered by the detectors during considered passing of the SAA area





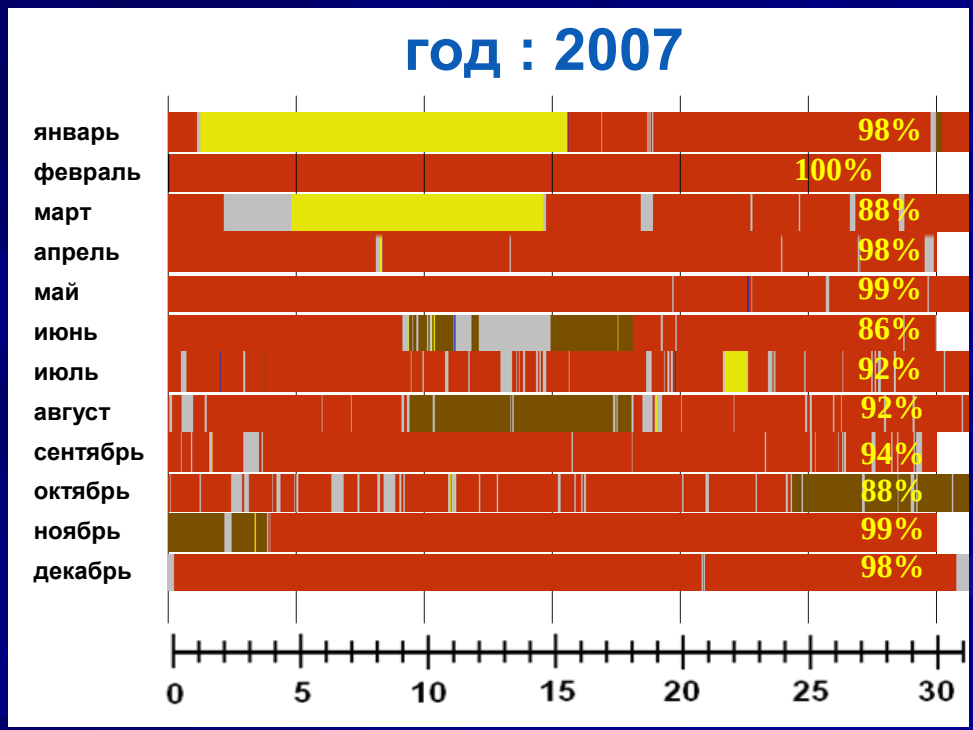
CONCLUSION

- The ISS attitude has an essential influence on dose value registered by the Liulin-5 in the SAA zone
- A change of the attitude may result into a change of the dose contribution into daily dose value more than three times.
- This effect is caused by the sharp non-isotropic shield distribution of the first and the second detectors of the Liulin-5 device during the experiment
- During one of the typical attitude the minimum shield zone of the detectors was directed to the side of maximum proton intensity that resulted into exceeded dose values

ACKNOWLEDGEMENTS

- Thanks the cosmonauts Oleg Kotov and Yuri Malenchenko for the operation of Liulin - 5 aboard ISS

Thank you for attention!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