Interactive Data Base of Cosmic Ray Anisotropy (DB A10)

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Content

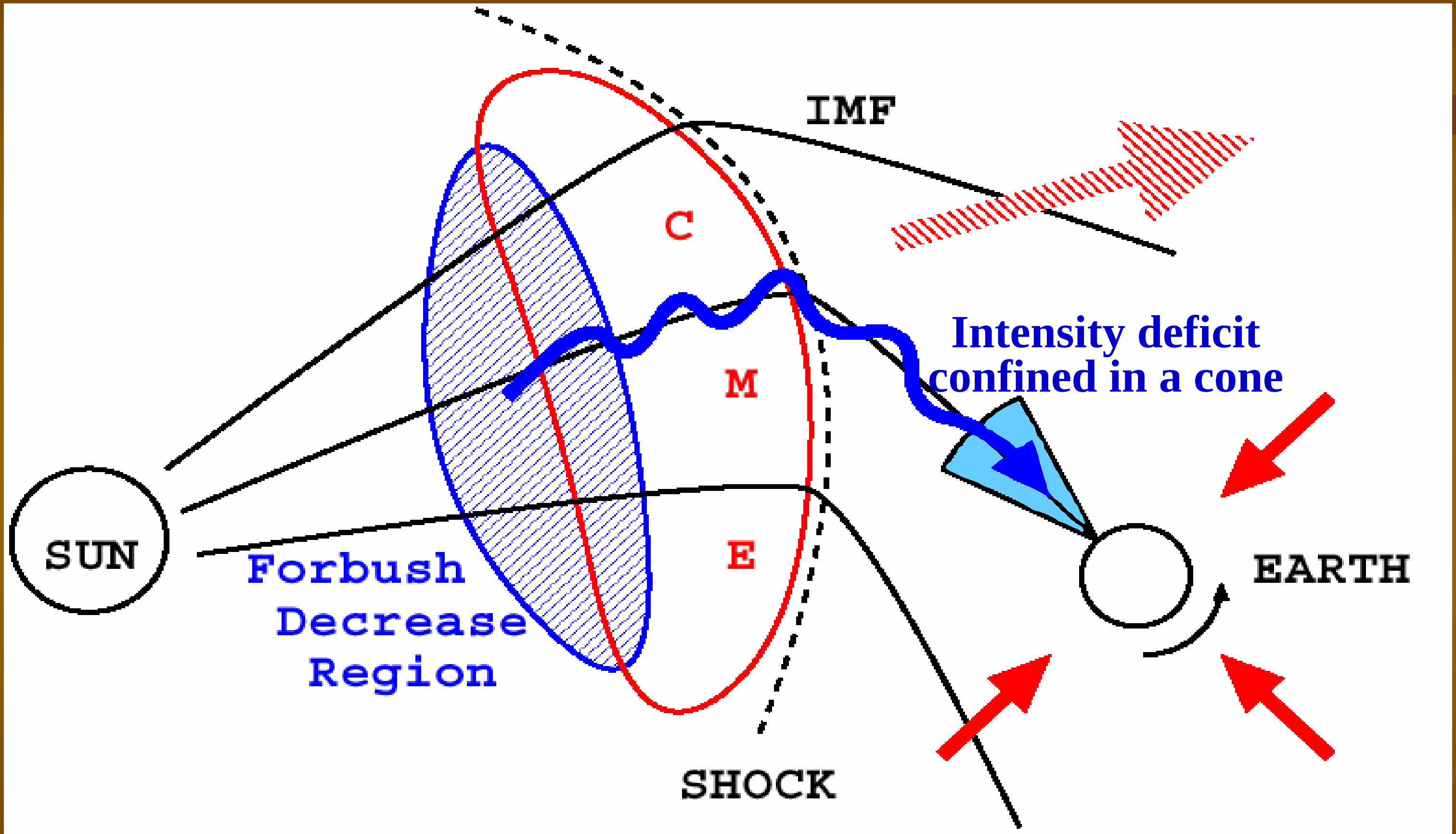
- Why anisotropy?
- Technique of separation
- General description
- Usage of DBA10
- Conclusion

Data on variations of CR density and anisotropy near Earth, beyond the magnetosphere are present for the cosmic rays of 10 GV rigidity. These are the global CR characteristics and they don't depend on the local position of detectors.

Why Anisotropy?

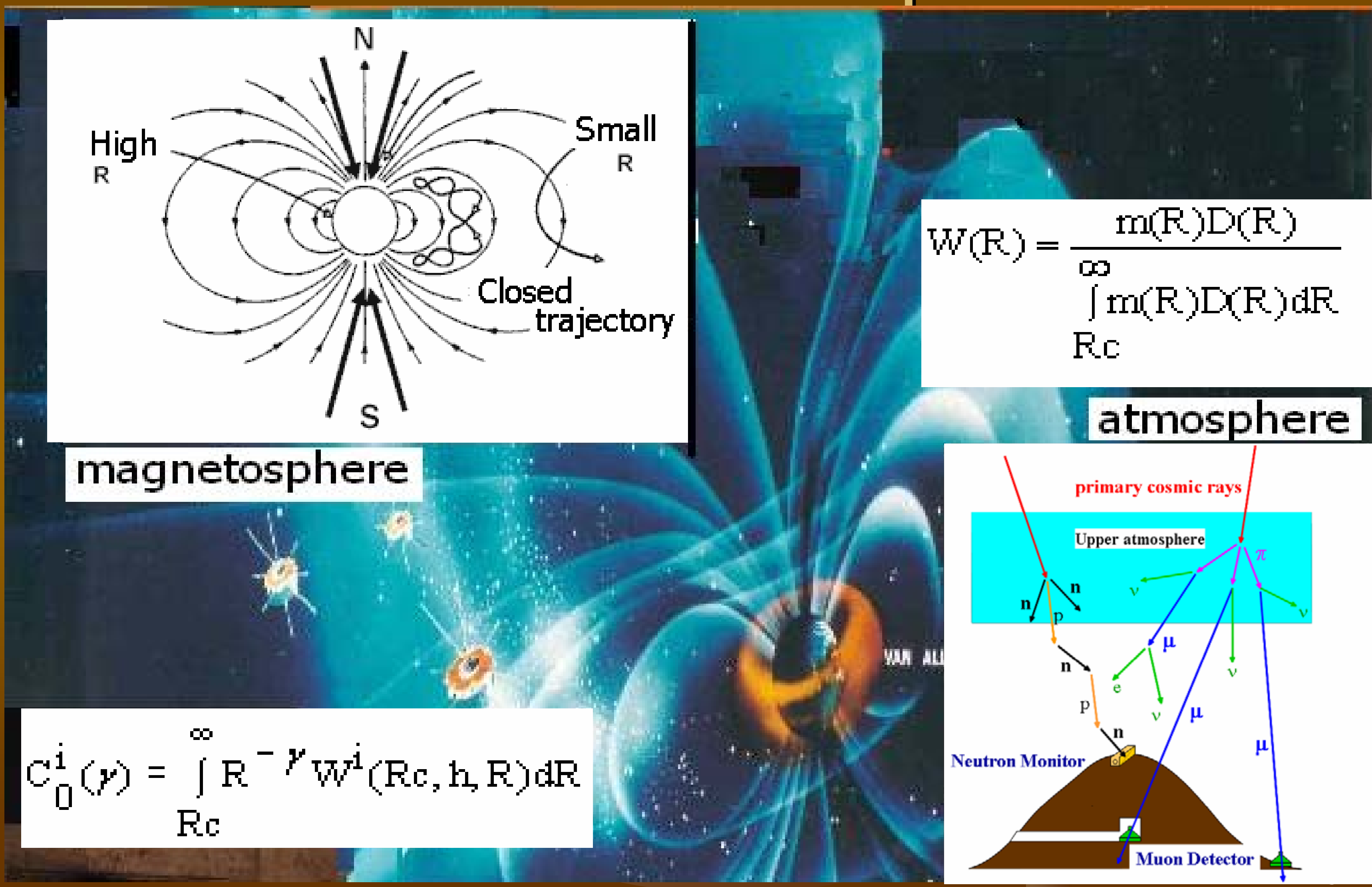
- The anisotropy of galactic cosmic rays in average is <1%. However, no other CR characteristic is capable to give so a lot of information on the conditions in the interplanetary space, as anisotropy.
- Structural features and processes in a solar wind in wide spatial (10**9 -10**14 cm) and time (10**3 – 10**8 s) ranges, are reflected in anisotropy CR observable on the Earth.
- CR density variations and other

Loss-cone precursor (Nagashima et al. [1992], Ruffolo [1999])



- CR pre-decreases before the FEs are caused by the magnetic channel connecting the Earth with a CR depleted region behind the shock.

Cosmic rays in the magnetosphere and Earth’s atmosphere



$$W(R) = \frac{m(R)D(R)}{\int_{Rc}^{\infty} m(R)D(R)\,dR}$$

$$C_0^i(\gamma) = \int_{Rc}^{\infty} R^{-\gamma} W^i(Rc, h, R)\,dR$$

Technique of separation

- The worldwide neutron monitor (NM) network is a unique tool for obtaining with high accuracy a density variations, energy spectrum and anisotropy of Comic Rays at the Earth orbit, outside its atmosphere and magnetosphere.

- We obtained these hourly average parameters for the whole period of the CR monitoring using the Global Survey Method (GSM-a complicated version of spherical analysis method).

Method of anisotropy separation

Being limited to the zero and first harmonics, CR variations recorded on the Earth at a point *i* during the moment of time *t*, are possible to be written down as:

$$\frac{\delta N^i}{N^i} = C_0^i(\gamma) \cdot a_0 + (C_x^i \cdot x' + C_y^i \cdot y' + C_z^i \cdot z')$$

Where C0, Cx, Cy, Cz are reception coefficients between CR variations outside the magnetosphere and variations observed at the ground, and they consider effect of magnetosphere and atmosphere.

a is the CR density (isotropic part);

(X, Y, Z)- three components of the CR anisotropy vector in the equatorial coordinate system;

- The solution of the equation system relative to the zero and first harmonics defines density *a*, its spectral characteristic ϒ and a vector of anisotropy of CR near to an orbit of the Earth outside its atmosphere and magnetosphere. Hourly average values of such sizes have been calculated by the data from up to 60 neutron monitors for all epoch of CR monitoring from 1957 till present time.
- These results are combined within the MySQL Database on the cosmic ray (CR) anisotropy (DB_A10). We have developed the Internet-project for supplying these data in different digital and graphical forms

List of data presented in Data base (DB_A10):

- Ao-CR density variations;
- Y-spectral index of zero harmonic of CR variation
- (X, Y, Z)- components of CR anisotropy vector in equatorial coordinate system;
- Axy-magnitude of the equatorial component of anisotropy;
- Φ-direction of the equatorial CR anisotropy;
- Sigma – residual discrepancy between a model and real measurements which characterizes a model adequacy;

γ

List of data presented in Data base (DB_A10):

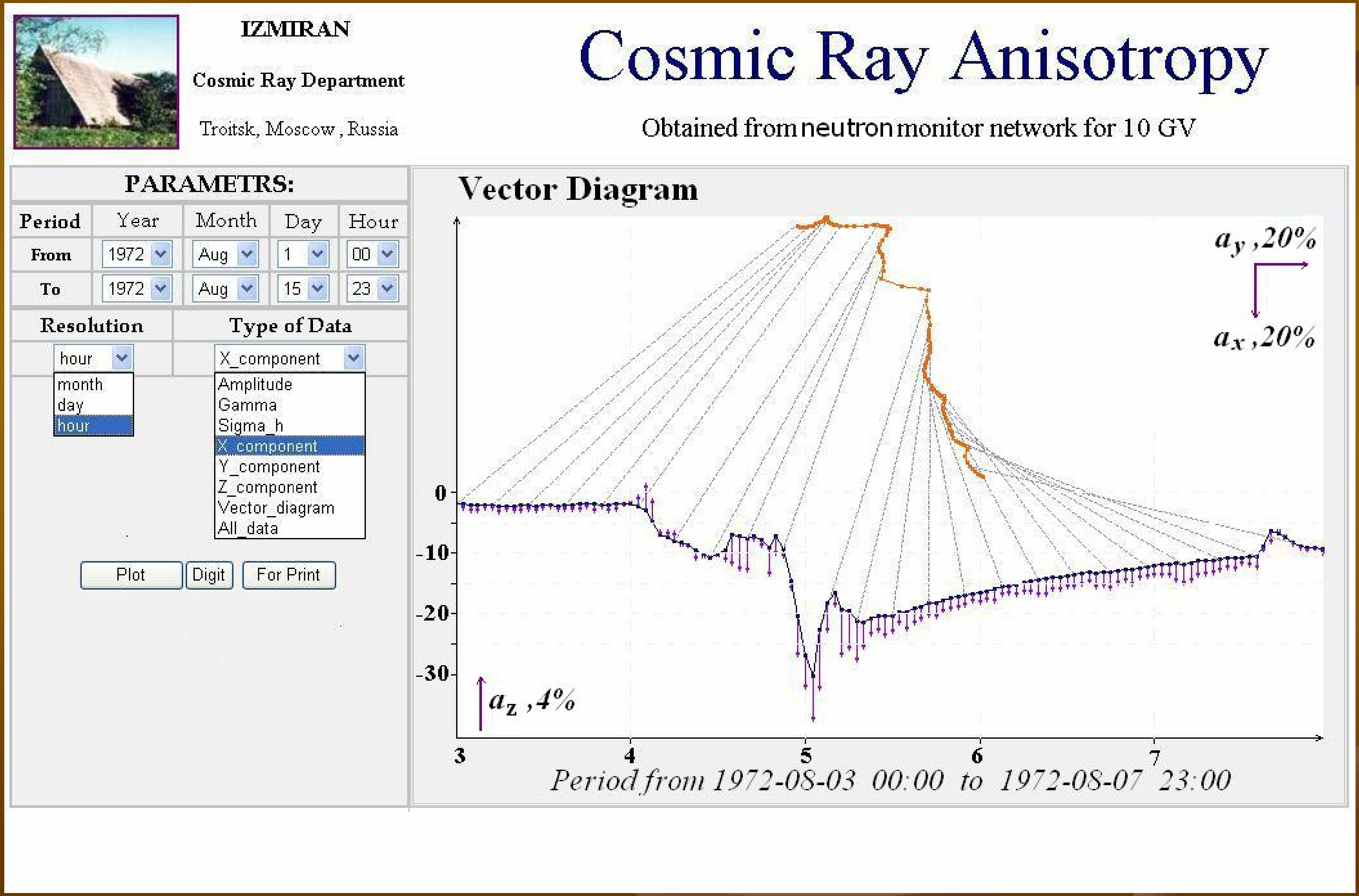
a_0	Density variations (zero harmonic) of CR with rigidity 10 GV in percentages relatively to 1976;
γ	Spectral index of zero harmonic variations, which is defined as $a_0 R^{-\gamma}$; index γ is derived for different basis periods and it may be used in the analysis within only short periods. In the next versions it will be normalized to a single basis;
(x, y, z)	Components of the CR anisotropy vector (10 GV particles) in the equatorial coordinate system, in percentages; variation of north-south anisotropy Z is derived with accuracy up to constant.
a_{xy}	Magnitude of the equatorial component of anisotropy (%);
φ	Direction of the equatorial component of CR anisotropy (in equatorial plane); 0 – is direction to the Sun;
sigma_H	Residual discrepancy between a model and real measurements for high latitude neutron monitors, which characterizes the model adequacy , in particular, indicates an availability of higher order harmonics;
sigma	Residual discrepancy between a total model of CR variations and real measurements at the neutron monitors from the whole set of NMs.

GRAFIC DATA PRESENTATION

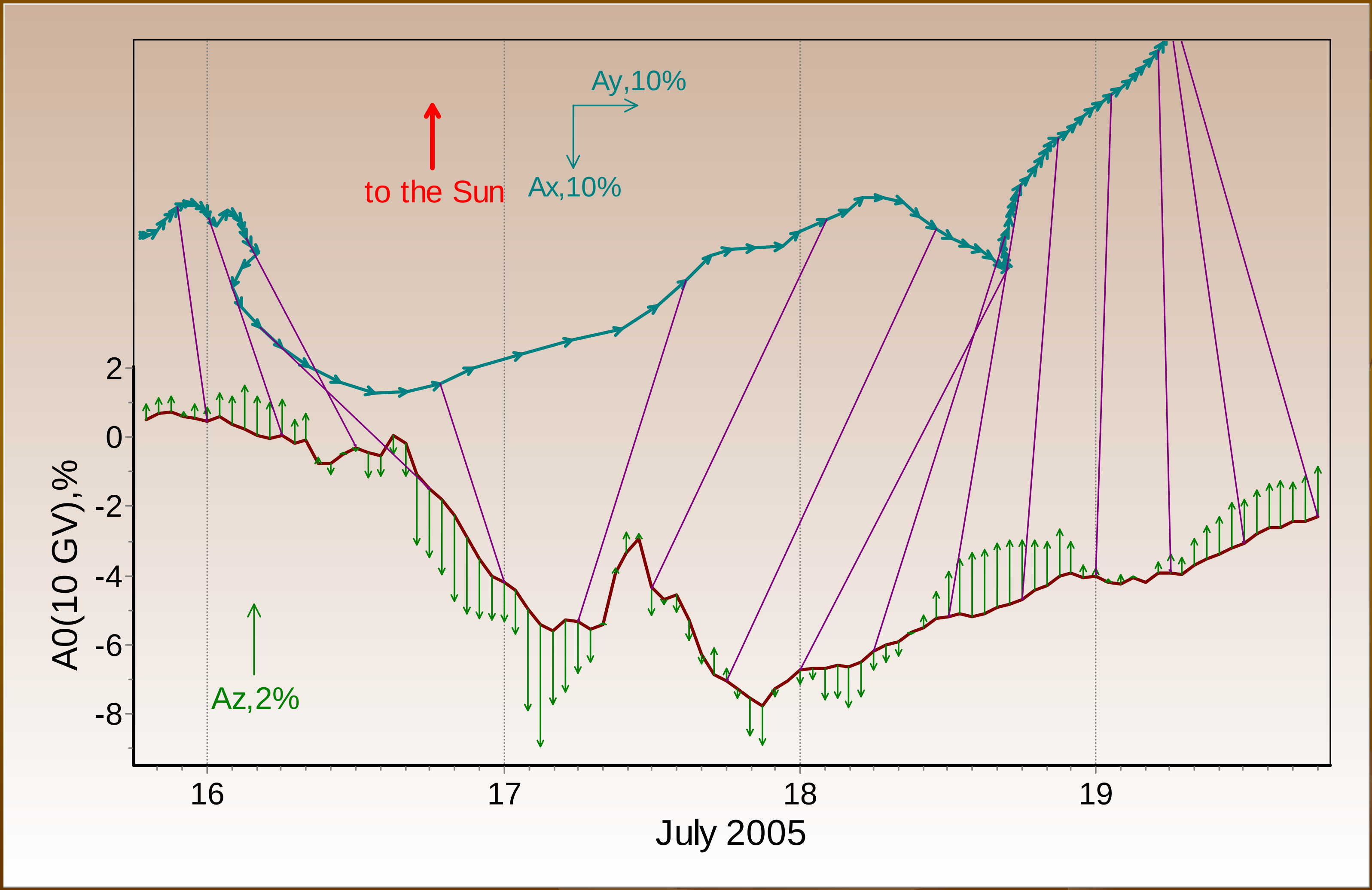
- Vector diagram - coupled vector diagram – direction and magnitude of equatorial component of CR anisotropy consequently from hour to hour. In the bottom part of picture a vector of north-south anisotropy *z* is shown along the time connected of CR density variation
- all Data- All parameters are plotted simultaneously: density variation (*a*), north-south anisotropy *z*, magnitude and direction of equatorial component of CR anisotropy.

Main Page (DB A10)

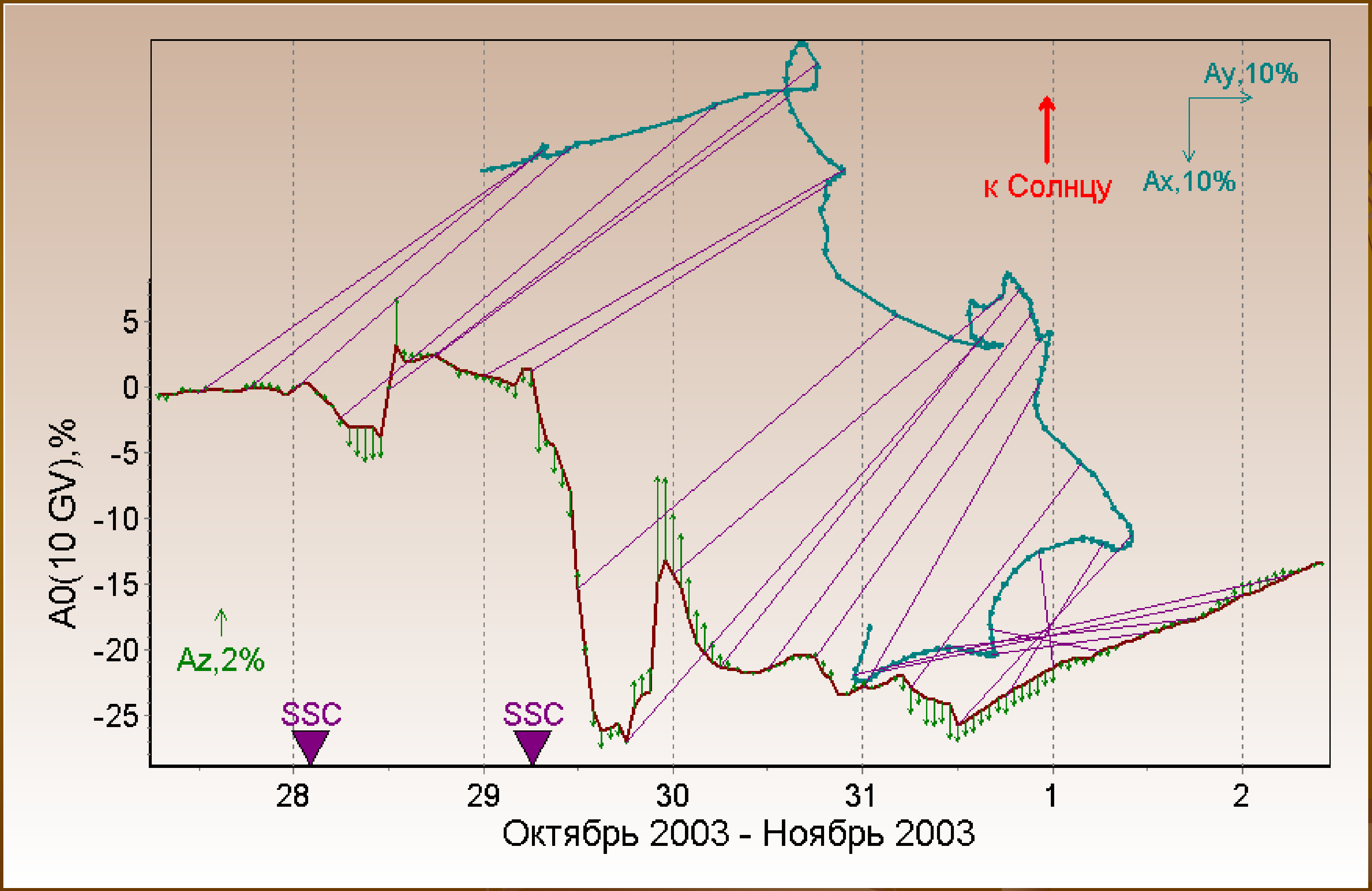
http://cr20.izmiran.ru/AnisotropyCR/Index.php



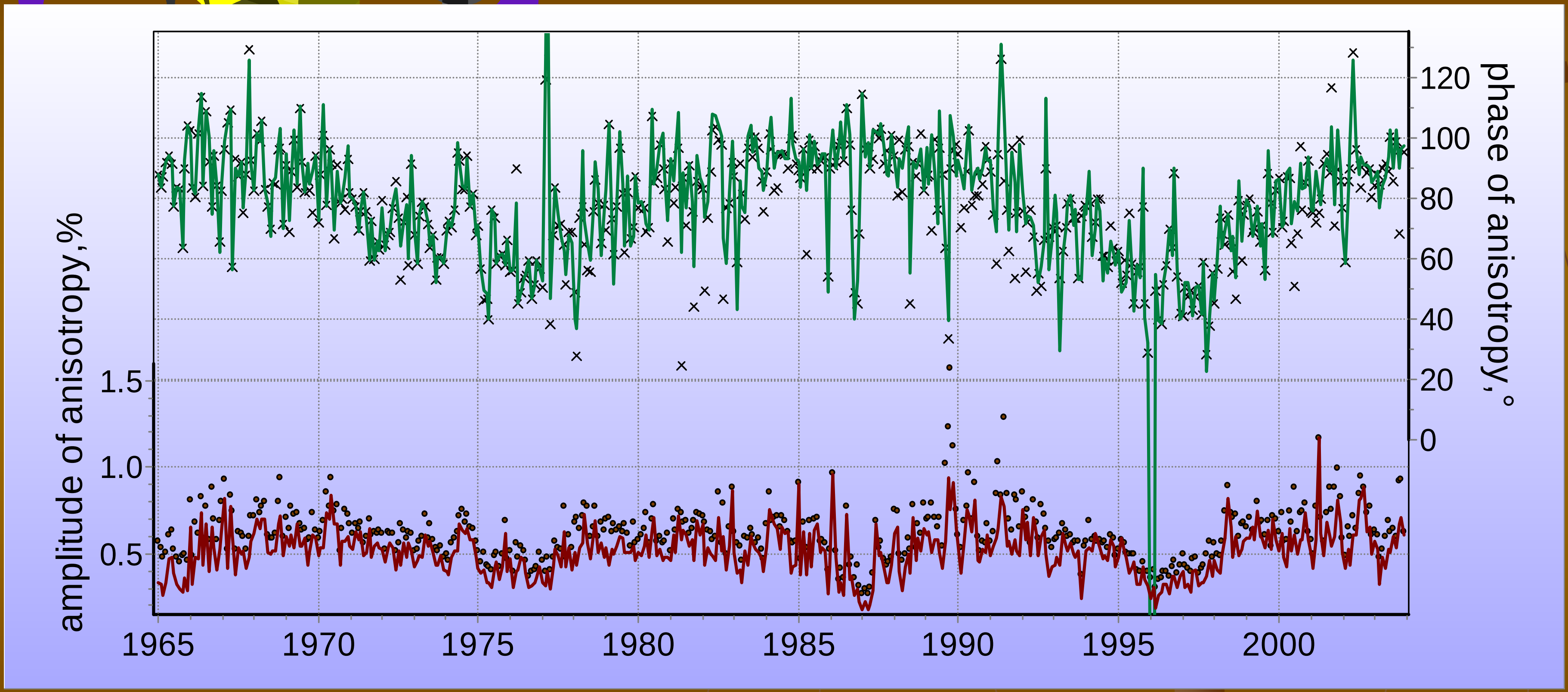
Graphic data presentation



Graphic data presentation

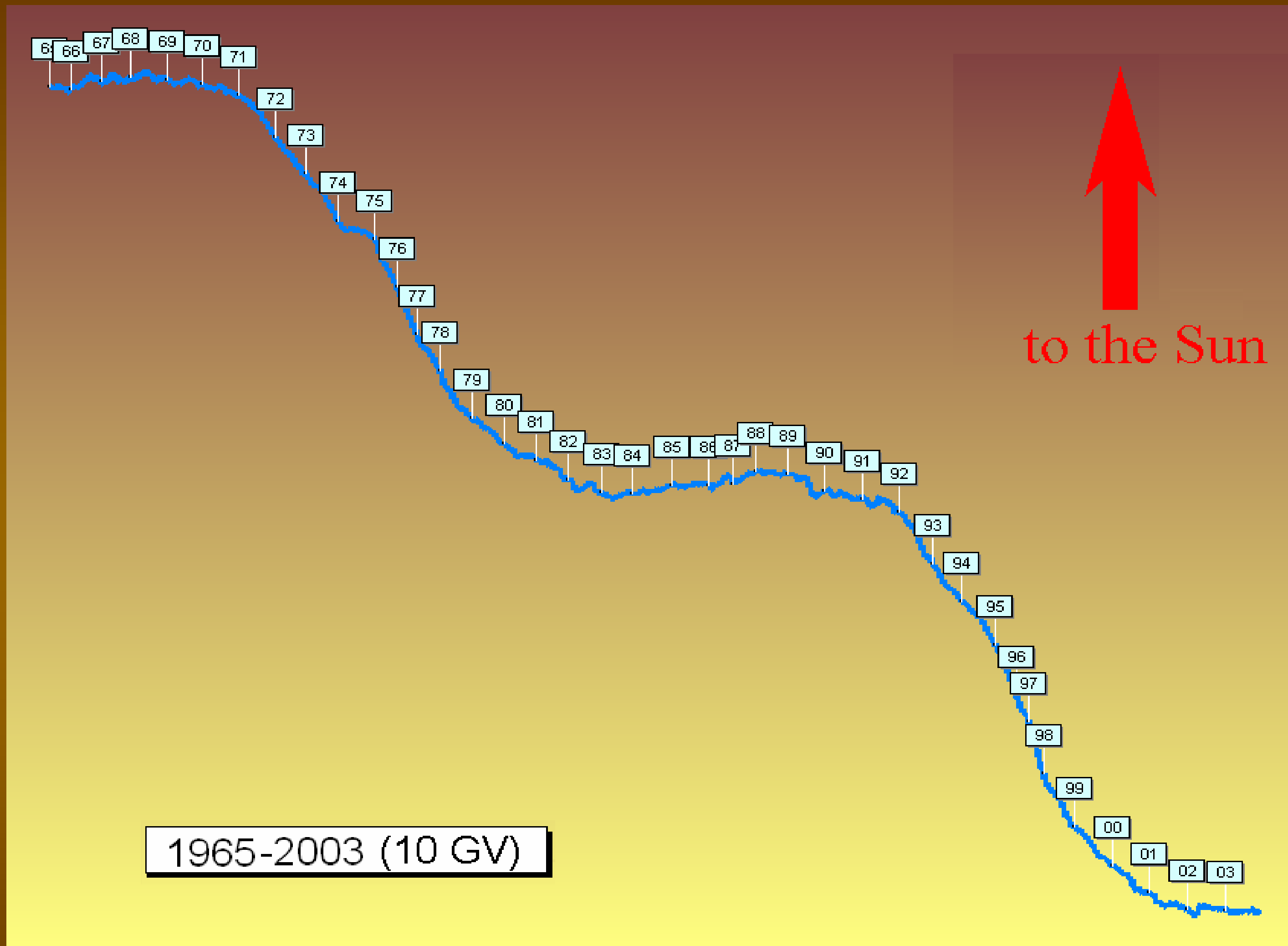


Parameters of the CR anisotropy



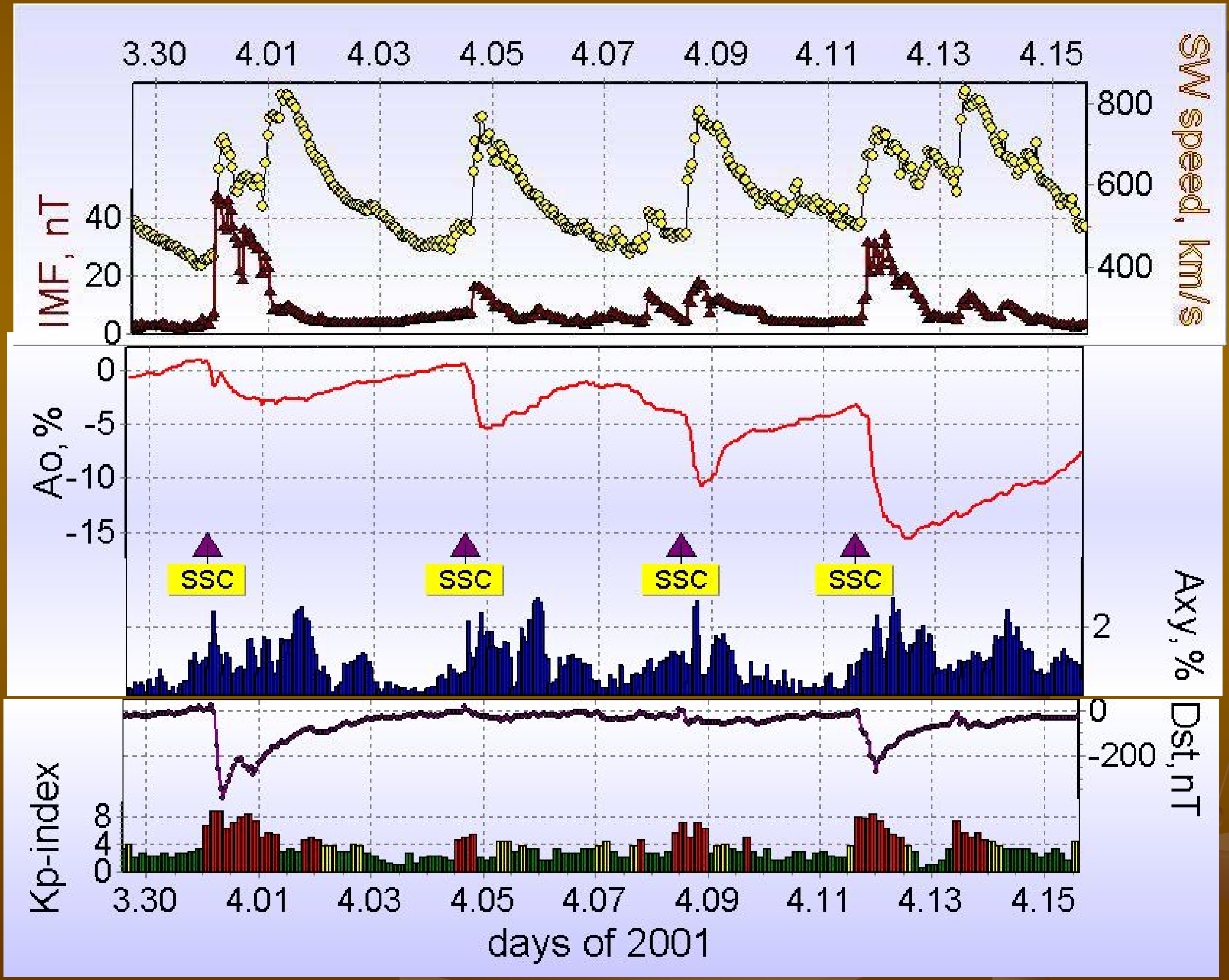
Long time behavior of the amplitude and phase of the CR anisotropy first harmonic

39 years, >340 000 arrays



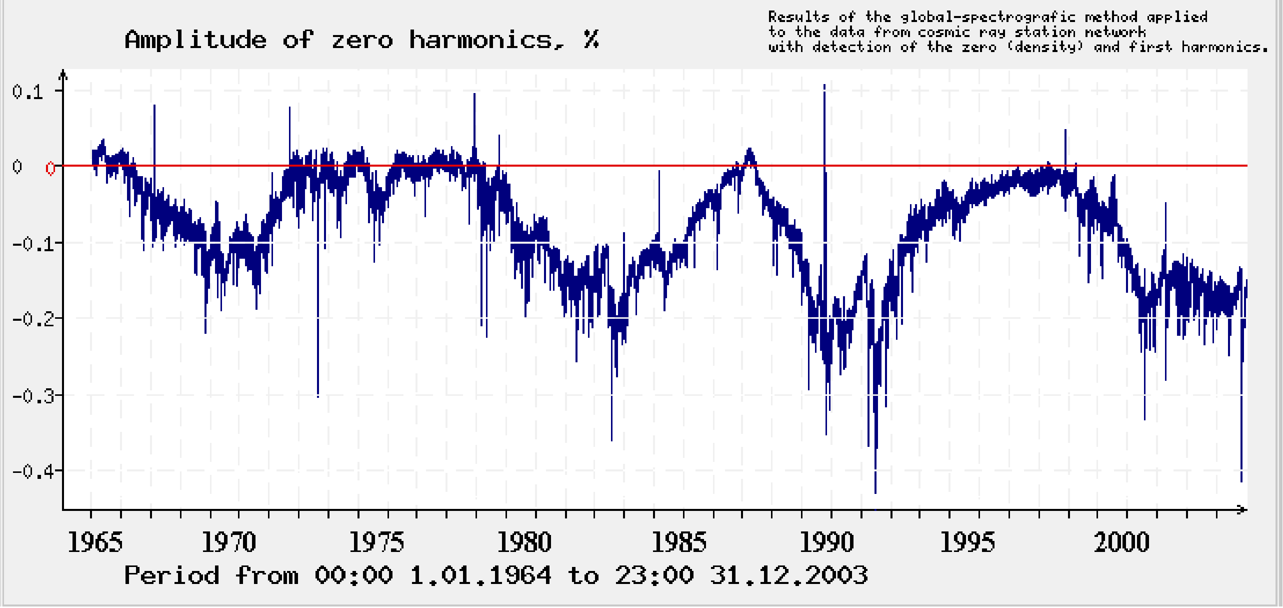
Solar-diurnal component of CR anisotropy (for 10 GV rigidity) during the period 1965-2003.

Example of series of Forbush effects in March-April 2001

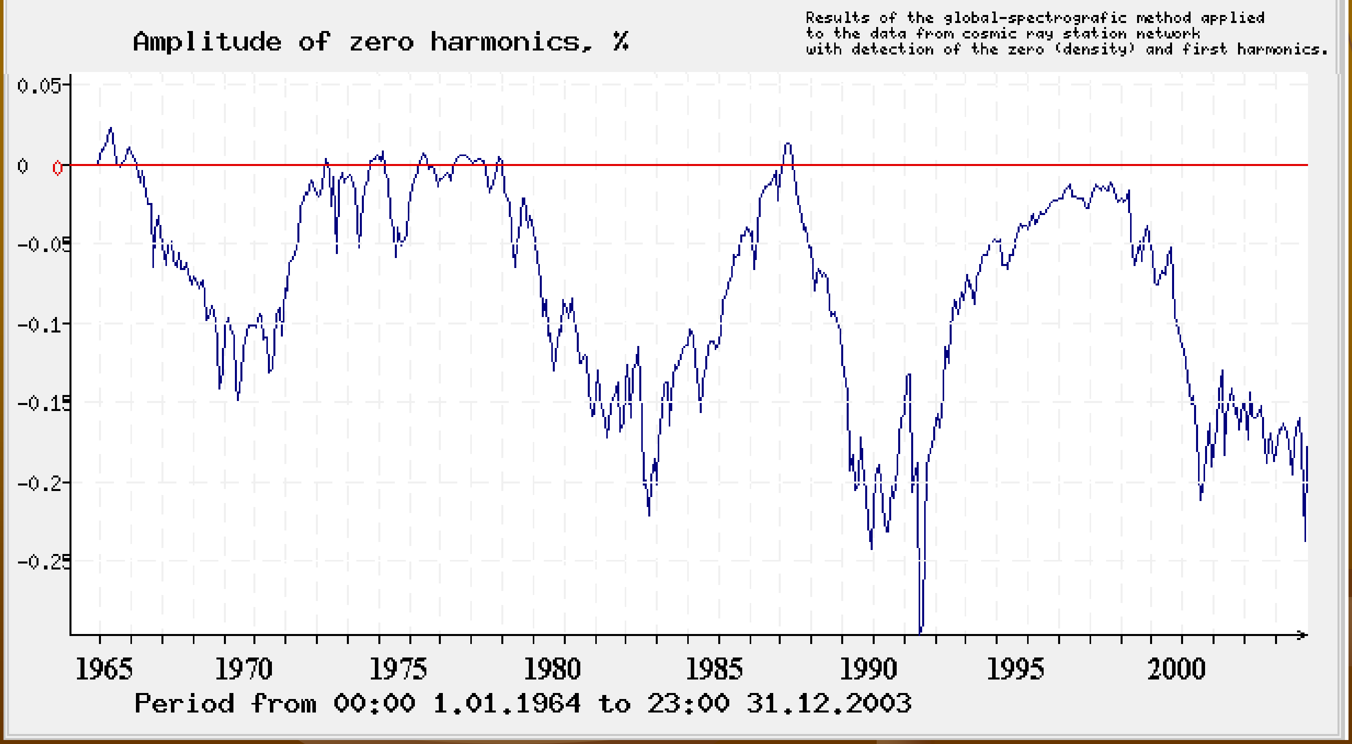


Grafic Data presentation

CR density variations by hourly data

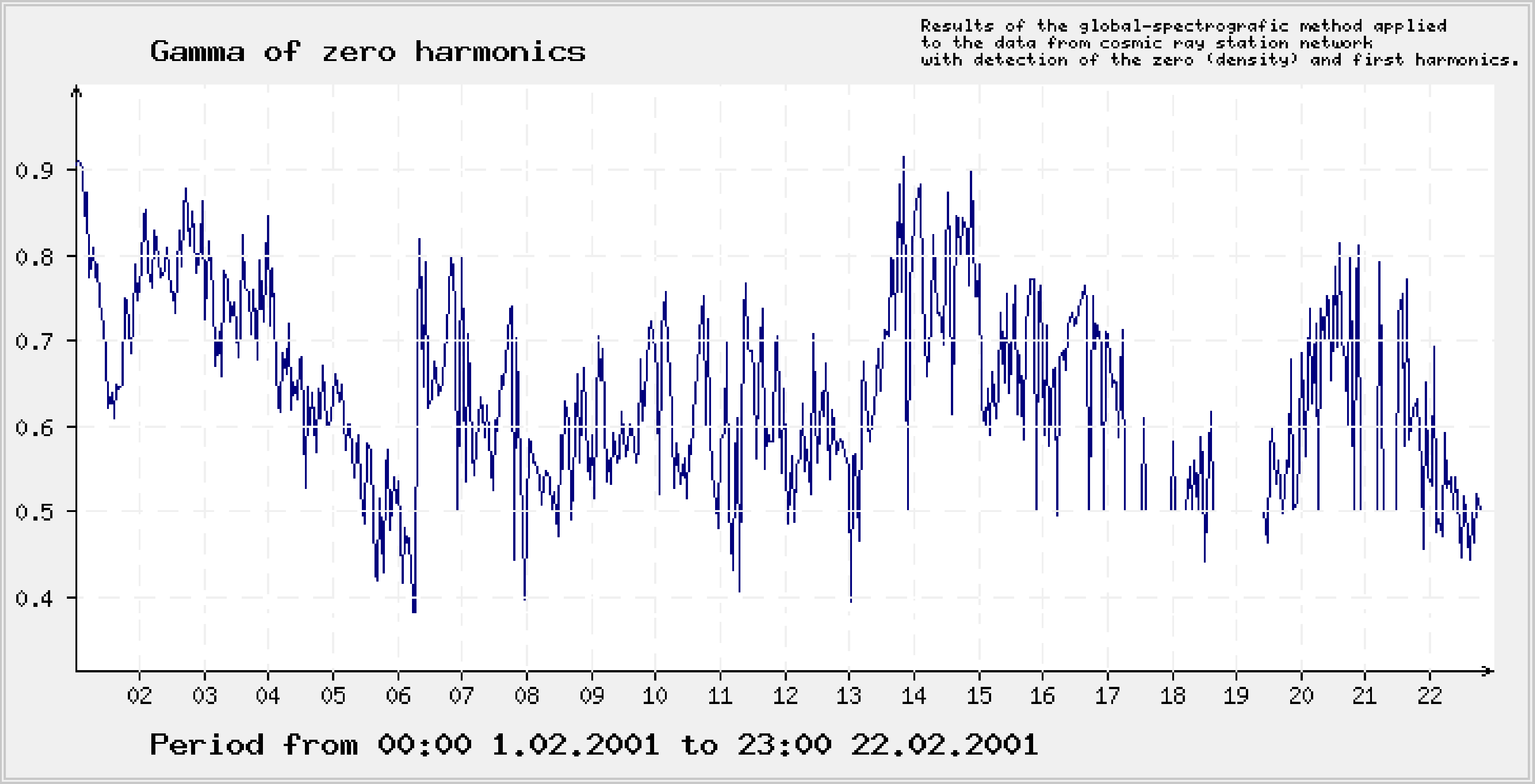


CR density variations by monthly data



a_0

Grafic Data presentation

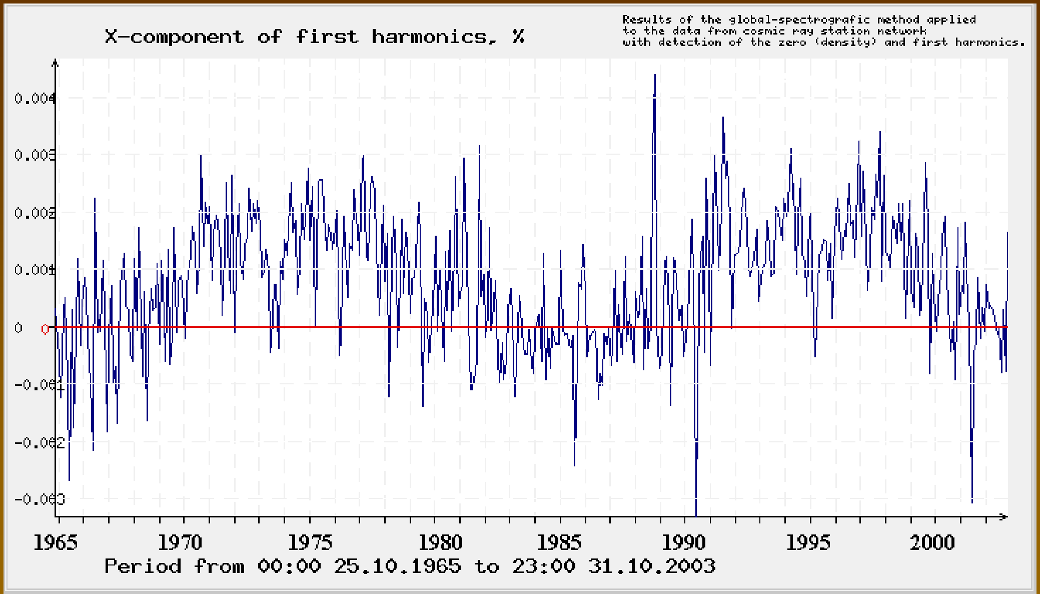


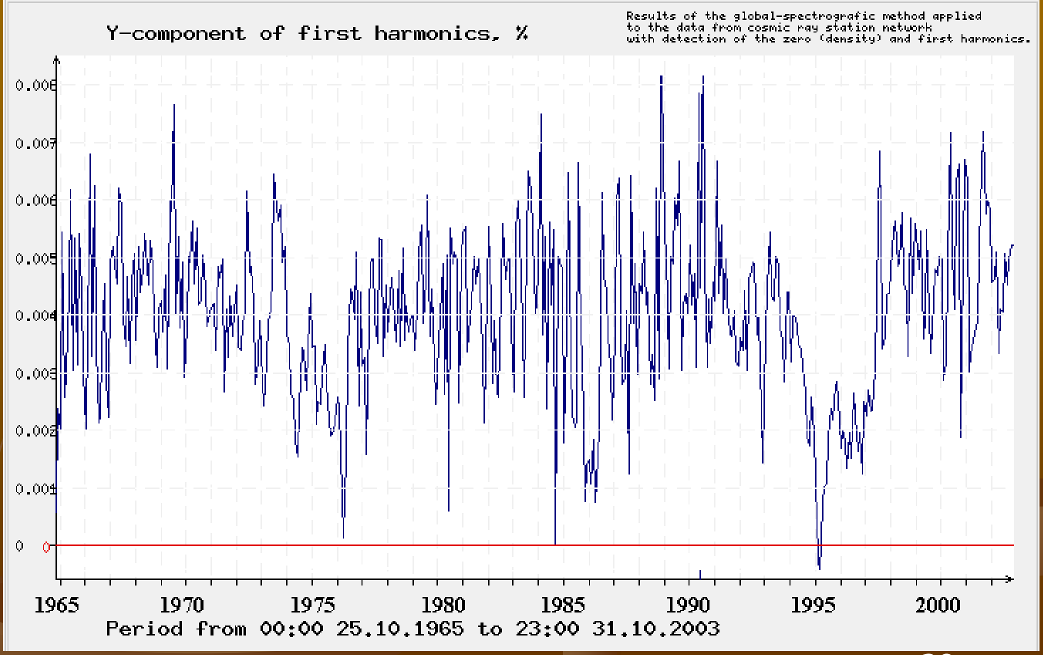
- Spectral index γ of zero harmonic variations, defined as $a_0 R^{-\gamma}$

is derived for different basis periods and it may be used within only short periods. In the next versions it will be normalized to a single basis;

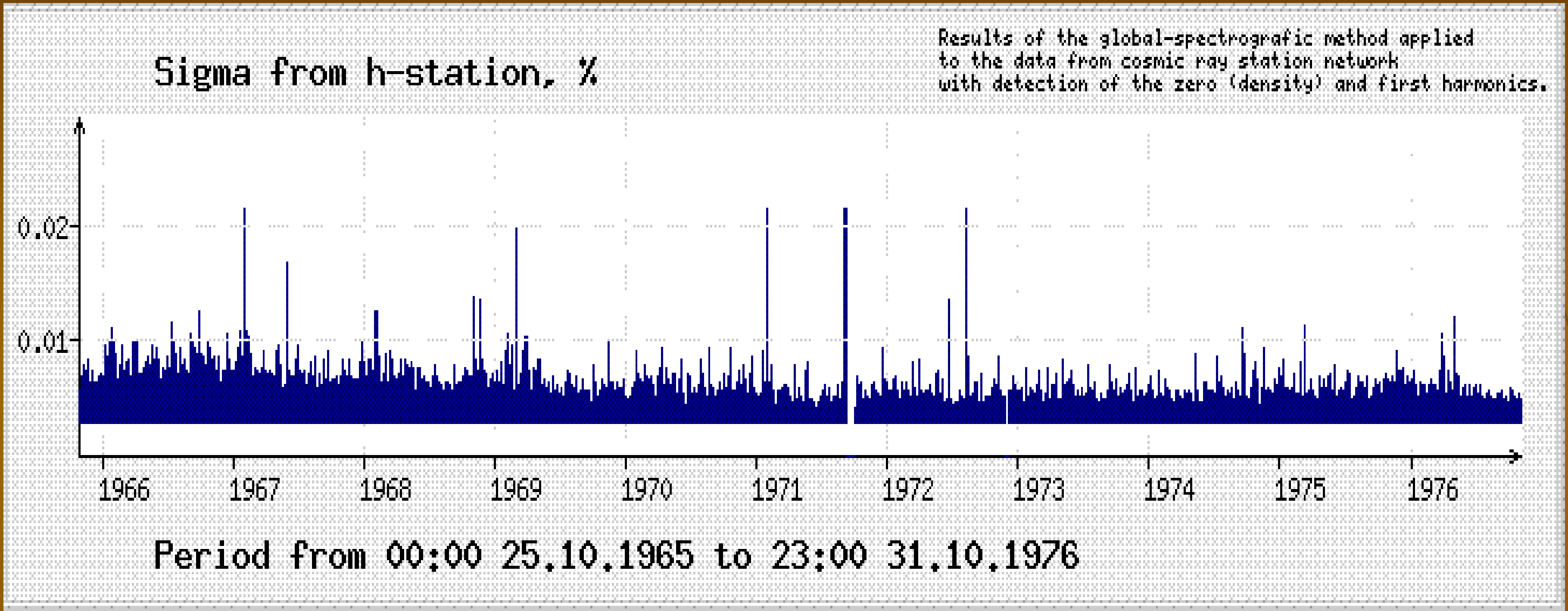
Grafic Data Presentation

X and Y components of the CR anisotropy (for 10 GV particles) obtained in the equatorial coordinate system (hourly data)



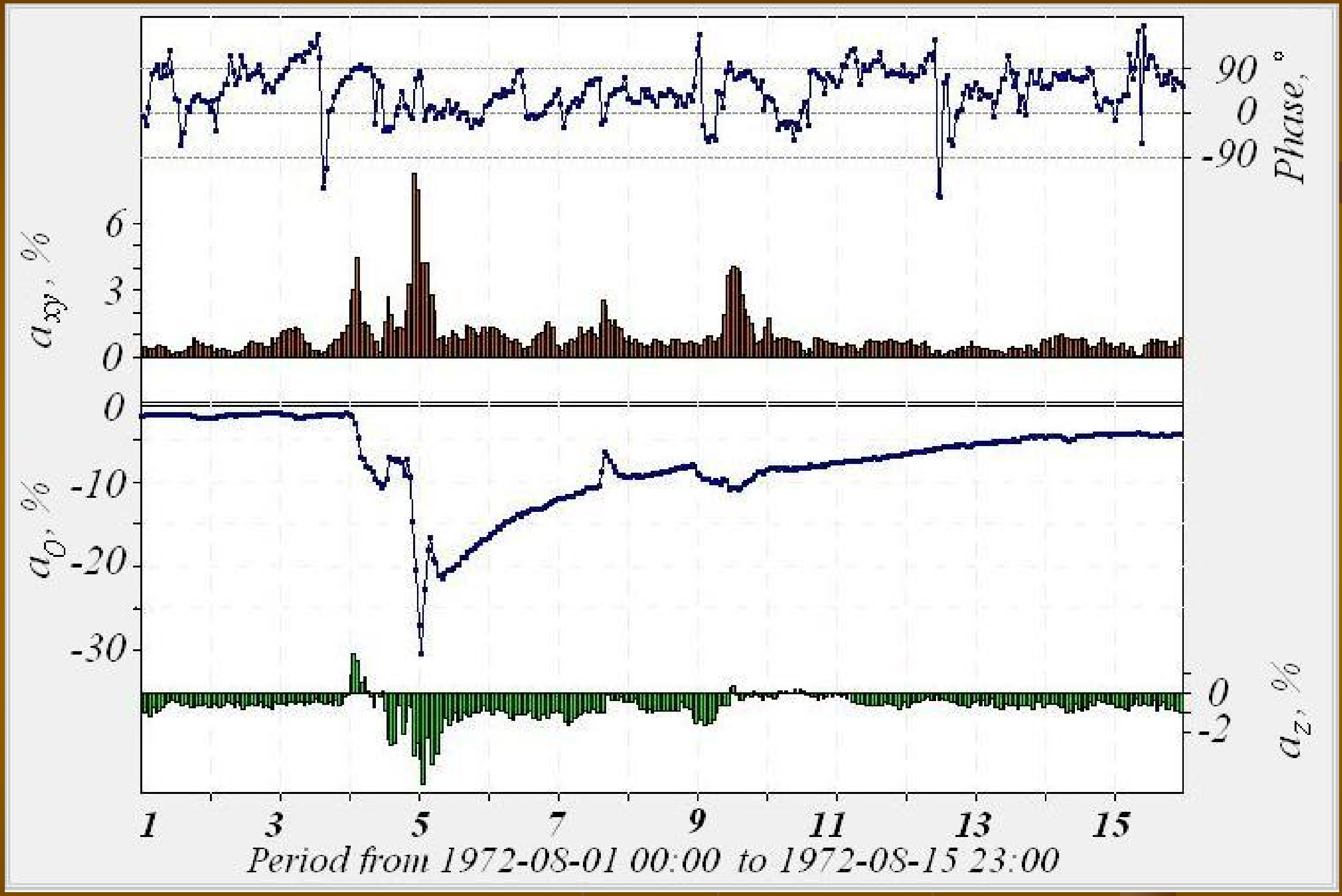


Grafic Data presentation



sigma_H Residual discrepancy between a model and real measurements for high latitude neutron monitors, which characterizes the model adequacy , in particular, indicates an availability of higher order harmonics;

Graphic data presentation



All parameters are plotted simultaneously: density variation , north-south anisotropy *z*, magnitude (Axy) and direction (Phase)of equatorial component of CR anisotropy.

Conclusion

A number of records in the DBA10 database is 450000, capacity 600 MB. Monthly updating, updating in real time is possible. Free access is available by the address:

- http://cr20.izmiran.rssi.ru/AnisotropyCR/Index.php.
- The interactive database DBA10 might be used for solving as pure scientific well as applied problems. The MySQL database for storage CR anisotropy and density data (10GV) and the user interface allow arranging requests of different structure, data coupling with external systems and databases, and their usage in different projects.

References

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- THANK YOU