Problems of reliability of the SEP data
SEP measurements on Electro-L

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Different stages of problems of SEP measurements reliability

– Instrument calibration itself;
– Artifacts of instrument functioning, data transfer and initial processing;
– Separation of the SEP fluxes from the background fluxes of galactic protons;
– Dependence from the spacecraft location, flux anisotropy, magnetic field configuration
– Dependence from the SEP source location on the Sun and spatial expansion of particles
Background integral fluxes of galactic protons with energies 10–30 MeV at different satellites outside the magnetosphere. Difference is >2 orders of magnitude.

Do we know the fluxes of galactic protons with energies 10–100 MeV?
Artifacts of instrument functioning, data transfer and initial processing

Example of anomalous short-time peak fluxes of >4, >10, >30 MeV protons by IMP-8 during 18 April – 4 May, 2001 (top), and fluxes of protons of 9–15 and 40–80 MeV by GOES-6 during 2–17 March 1987 (bottom).
Integral proton fluxes on ACE during strong solar flares are clipped by \( \approx 4700 \text{ cm}^{-2} \cdot \text{s}^{-1} \cdot \text{sr}^{-1} \) for >10 MeV, and \( \approx 1900 \text{ cm}^{-2} \cdot \text{s}^{-1} \cdot \text{sr}^{-1} \) for >30 MeV (bold line). For comparison fluxes of >30 MeV protons on IMP-8 (thin dark line) and GOES-10 (light line) are given for 2 strong events in November 2000 and 2001.
Artifacts of instrument functioning, data transfer and initial processing

Top: integral fluxes of >10 and >60 MeV protons on IMP-8; middle: separately background galactic proton fluxes; bottom: exponent of energy spectra of 10-year interplanetary proton fluences with energies from >1 to >60 MeV (this parameter depends mainly on solar proton fluxes). All parameters experience change after the middle of 1989 due to failure of anti-coincidence contour.
Statistical method of separating SEP fluxes from the background galactic proton fluxes. Smoothed monthly maximum value of background flux is determined as a “knee” in the flux distribution.

The method does not work for the proton energies <4–5 MeV. For example, below the fluxes of >1 MeV protons on IMP-8 during the same 3-months period are shown. The value distribution does not have an evident “knee”. We can conclude that the type of contribution of various sources to the fluxes of <4 MeV protons differs from that for >4 MeV.
Dependence from the spacecraft location and flux anisotropy

Top: >10 MeV proton fluxes in 1) January 31 and 2) October 30, 1991 SPEs from IMP-8 (bold curves) and GOES-6 (thin); 3) Jun 7 and 10, 2000 SPEs from IMP-8 (bold curve) and ACE (thin). Bottom plots: the location of IMP-8 in X and Y GSE-coordinates for the corresponding time intervals. It appears that the fluxes measured by IMP-8 becomes lower, when it is located inside the magnetosheath region.
Observed inside-outside difference depends mainly on direction of interplanetary magnetic field, on degree of the SEP anisotropy (pitch-angle distribution) in IMF, and on distance of the magnetopause from the Earth.
Penetration of Solar Cosmic Rays into the Earth’s Magnetosphere on January 28, 2012


The decrease of the efficiency of SCR penetration into the Earth’s magnetosphere in the region of the orbits under study on January 28, 2012, is related to the passage of the Earth’s magnetosphere through the interplanetary environment structure with a quasi-radial interplanetary magnetic field and a small pressure of the solar wind.

Figure. Time profiles of SCR fluxes and Bx,y-components of IMF
Dependence from location of SEP source on the Sun and particle propagation

Distribution of >30 MeV SEP fluences in ≈420 solar proton events 19–24 solar cycles over their source longitude relative to central visible meridian of the Sun. The maximum of the distribution is located in vicinity of the central meridian. Overall asymmetry of ≈10° towards west is present.

Requirements for an “ideal experiment”

- Detectors with known parameters, known placement on the spacecraft, 3D-modeling, intercalibrating;
- Long-term measurements;
- Wide energy range (for example, there is a difference in contributions of different sources for the energies $<1$ and $>5$ MeV);
- Uninterrupted energy range;
- Presence of the information about algorithms of initial data proceeding and correction
- Presence of the information about spatial orientation of the detectors;
- Data on flux anisotropy: several detectors with different orientation;
- Several spacecraft: observing the Sun from different positions (STEREO);
- Spacecraft in GEO, in the orbits crossing both the Earth’s magnetosphere and the interplanetary space, and outer-magnetospheric spacecraft (Sun-Earth L1 point etc.);
- MANY satellites: analyzing the particle propagation dynamics
SEP measurements on a GEO satellite Electro-L: SKL-E instrument

Launch: 20 Nov. 2011
Lifetime: 10 years
GEO Position: 76° east
Mass: 1766 kg
Application: meteorology

http://smdc.sinp.msu.ru/

128 Mpx full Earth images

SKL-E spectrometer parameters

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SEP measurements on a GEO satellite Electro-L: SKL-E instrument

Integral fluxes of >10 (top plot) and >30 MeV (bottom) protons measured by Electro-L (bold lines) and GOES-15 (thin lines) during 2 strong solar proton events in the end of January, 2012. A good coincidence is observed.
Correlation of >10 (left) and >30 MeV (right) proton fluxes on Electro-L and GOES-15 during several strong solar proton events in 2012.

Conclusions

- The calibration of the detector itself is only one part of the problem of SEP measurement reliability; various other factors have been considered during this talk.

- A suggested statistical method of separating the SEP fluxes from the background fluxes can be taken as a supplemental method for constructing the long-term intercalibrated data set of SEP fluxes.

- Considered dependencies of solar proton fluxes from the flux anisotropy and particles propagation in the interplanetary and near-Earth’s environment demand further study.

- Current SEP measurements on the geostationary satellite Electro-L have been presented.