CORONAS-F measurements of high-energy solar proton spectra

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Abstract

Fluxes of protons at the energies 0.5 - 3 GeV accelerated during solar flares of October-November 2003 were detected onboard the CORONAS-F satellite using an effect of geomagnetic cut-off. We calculated solar proton spectra on 28 and 29 October flares.

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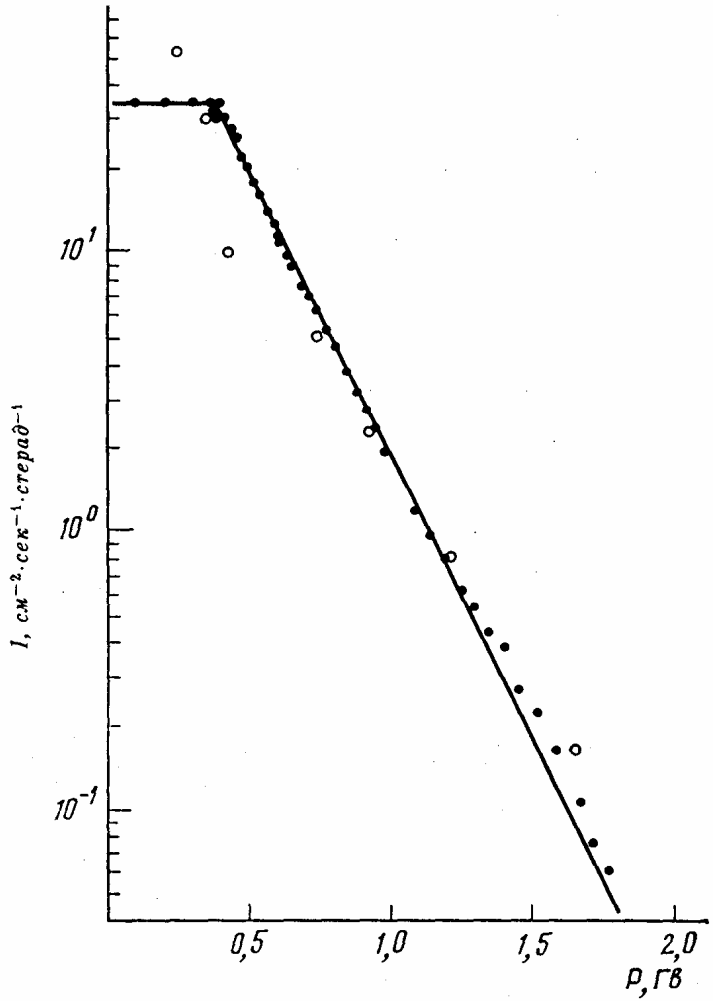
Methods of measurements of high-energy solar protons (up to a few GeV):

- direct measurement in interplanetary space by heavy and complicated detectors;
- using of the geomagnetic field as a geomagnetic spectrometer:
  - by the global NM network
  - by detectors on near-Earth satellites

SEP integral spectrum of solar flare 2 September 1971 (Shavrin et al, 1976)



Points – data of MOLNIYA-1 (Shavrin et al, 1976),

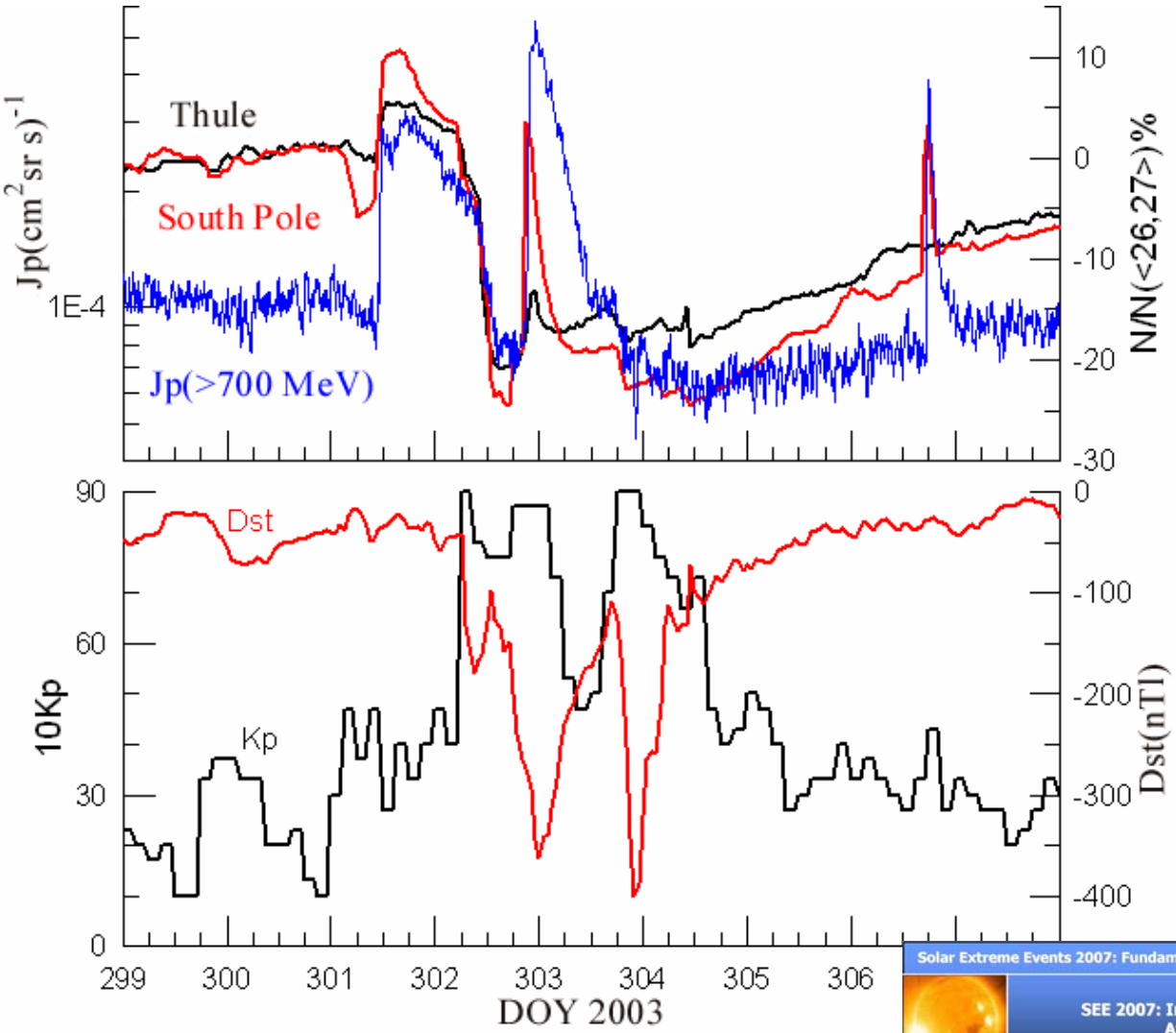
Open circles – COSMOS-426 (Vernov et al., 1973).

Heristhi and Trottet (1975) pointed to a difference between NM and COSMOS-426 data.

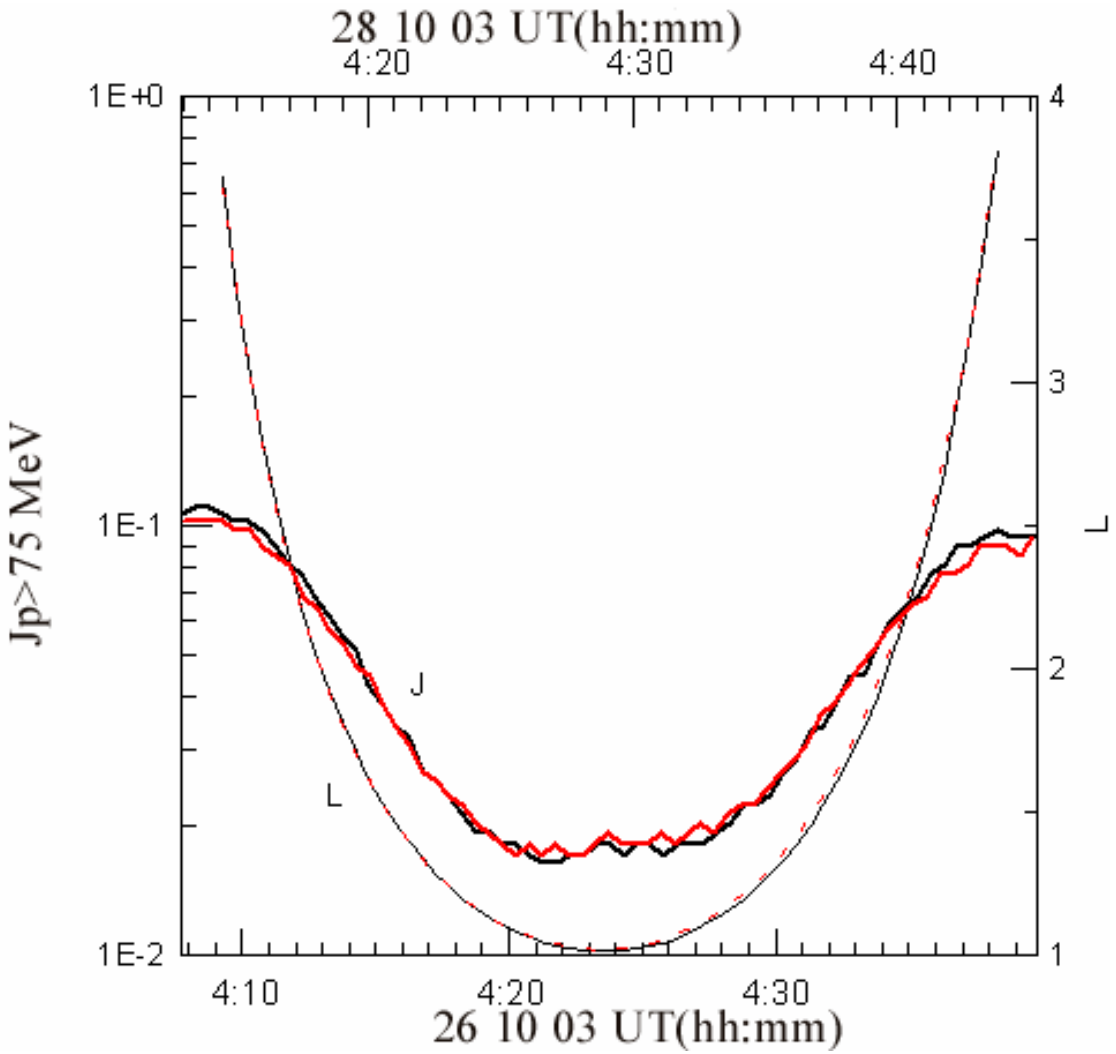
CORONAS-F: altitude 450 km,
orbit inclination 82º.

SONG instrument: CsI crystal, Ø 200 mm,
height 100 mm.
Geometric factor ~ 1500 cm^2 sr
(protons > 75 MeV).

Particle fluxes and geomagnetic conditions



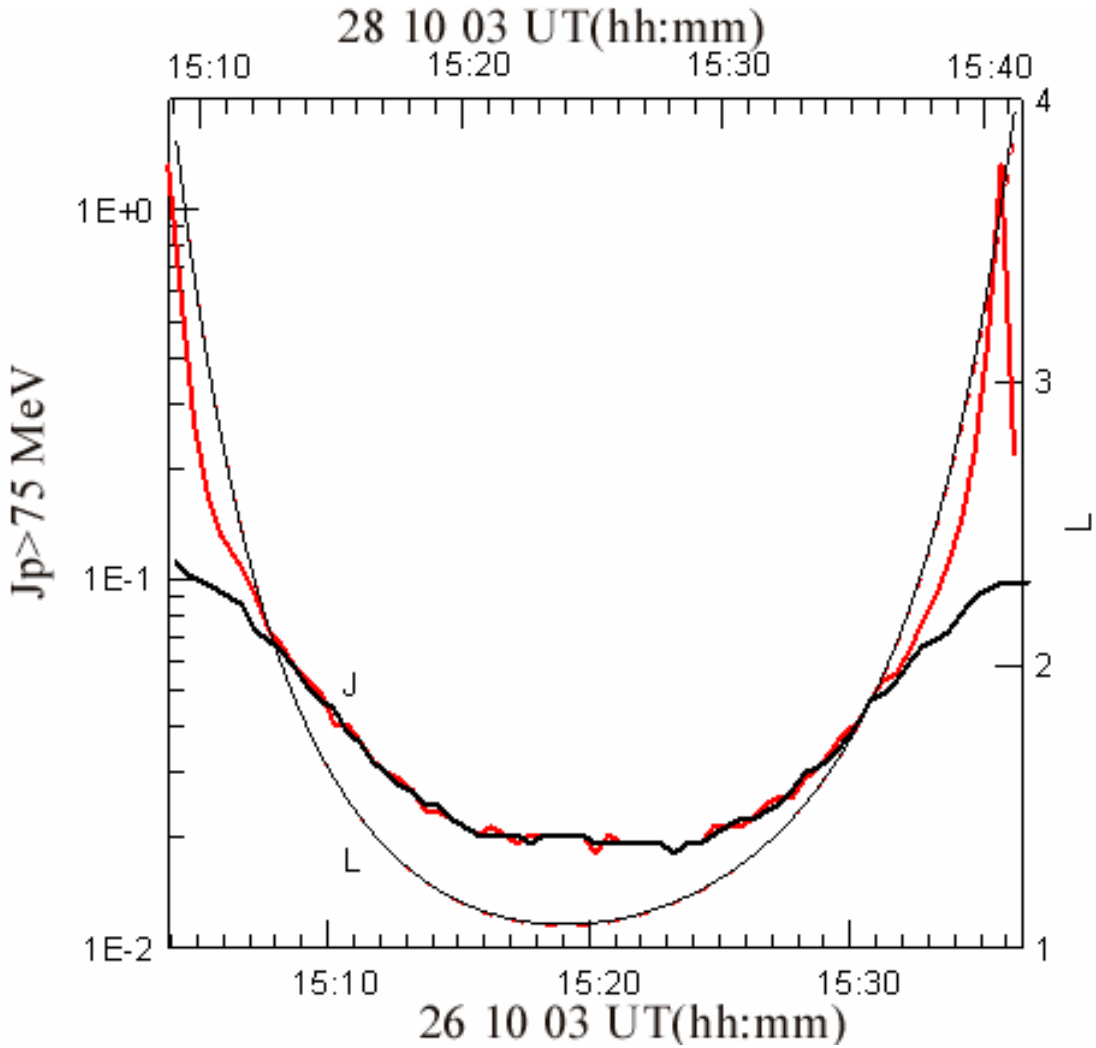
Observations of high-energy proton fluxes before the solar flare of 28 October 2003



26 October

28 October

Observations of high-energy solar proton fluxes during the solar flare of 28 October 2003



26 October

28 October

Vertical effective rigidities of geomagnetic cut-off of satellite orbit locations were calculated by numerical calculations of particle trajectories.

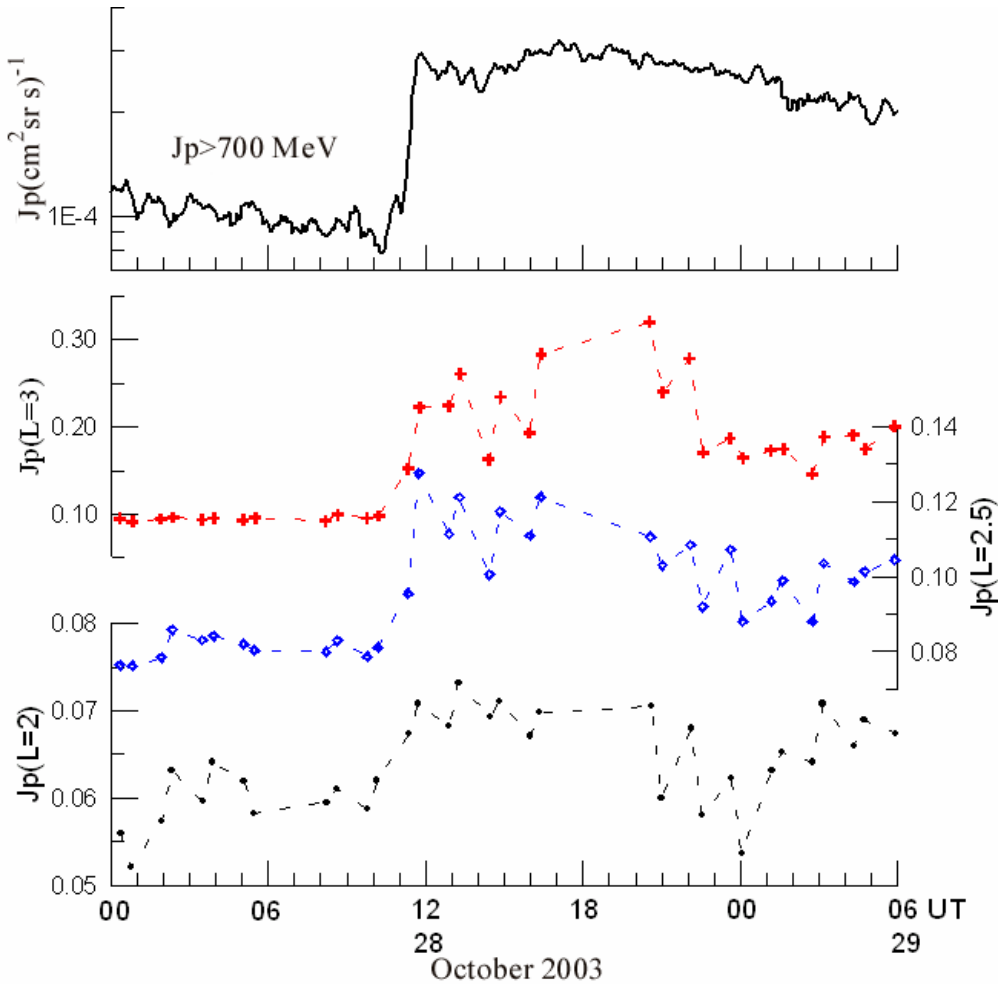
The geomagnetic field was described by

IGRF

+ Tsyganenko-89 model

+ Boberg's extension for 29 October 2003.

Solar energetic protons enhancement on 28 October 2003



GOES-10

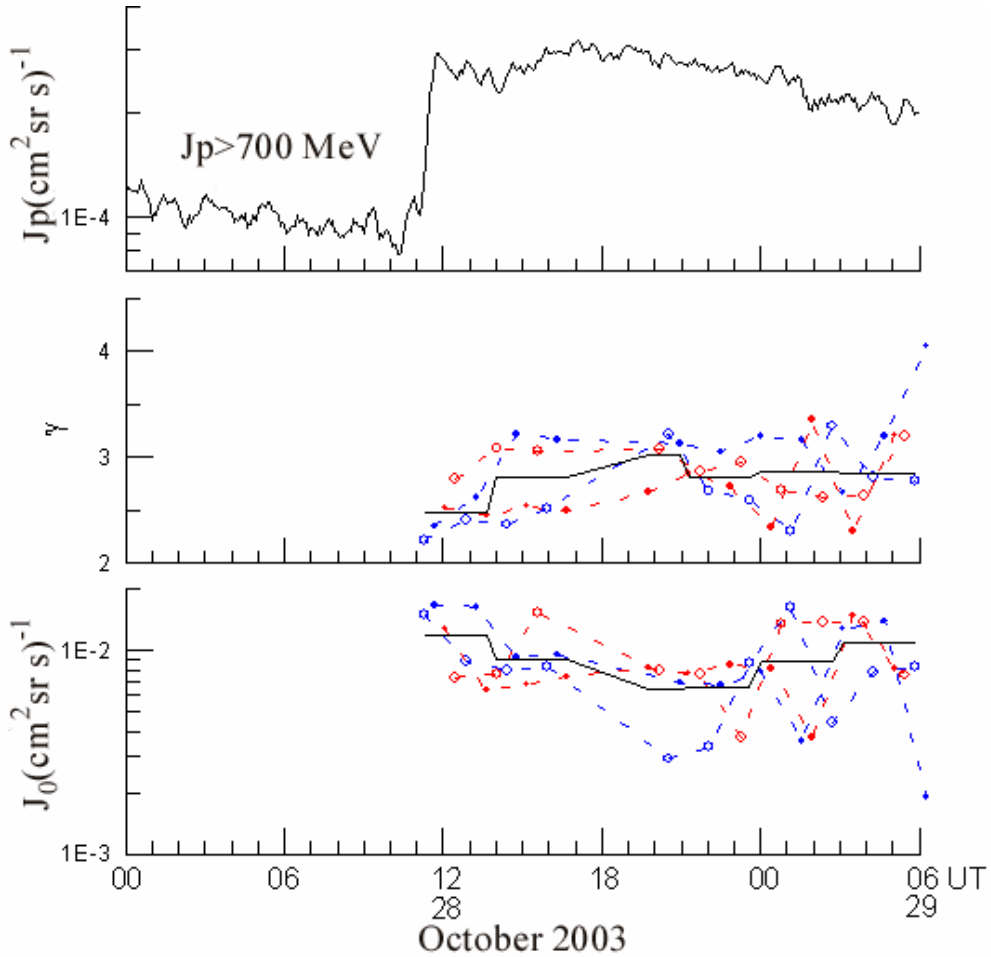
CORONAS-F

L=3 (R>0.85 GV)

L=2.5 (R>1.5 GV)

L=2 (R>3 GV)

Dynamics of solar proton fluxes before SSC



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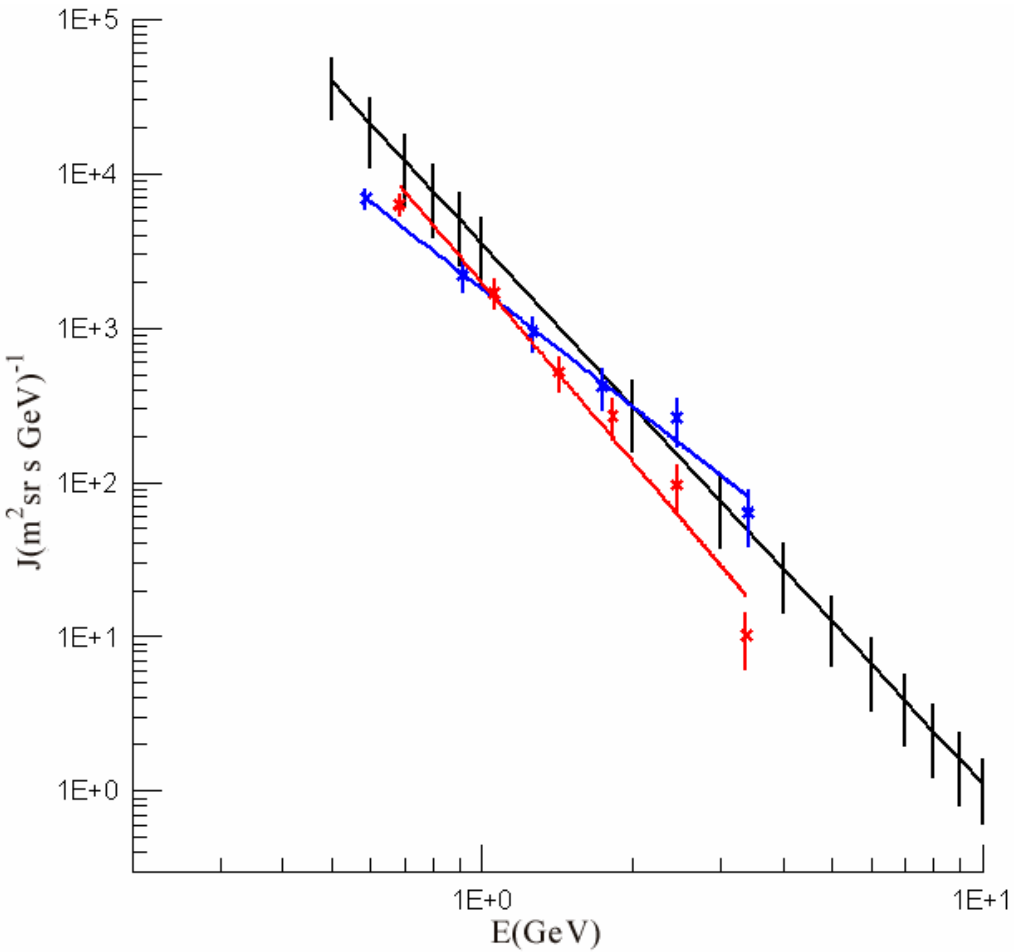
CORONAS-F:

$$J(>E) = J_0 E^{-\gamma}$$

Solar proton spectra on 28 October 2003



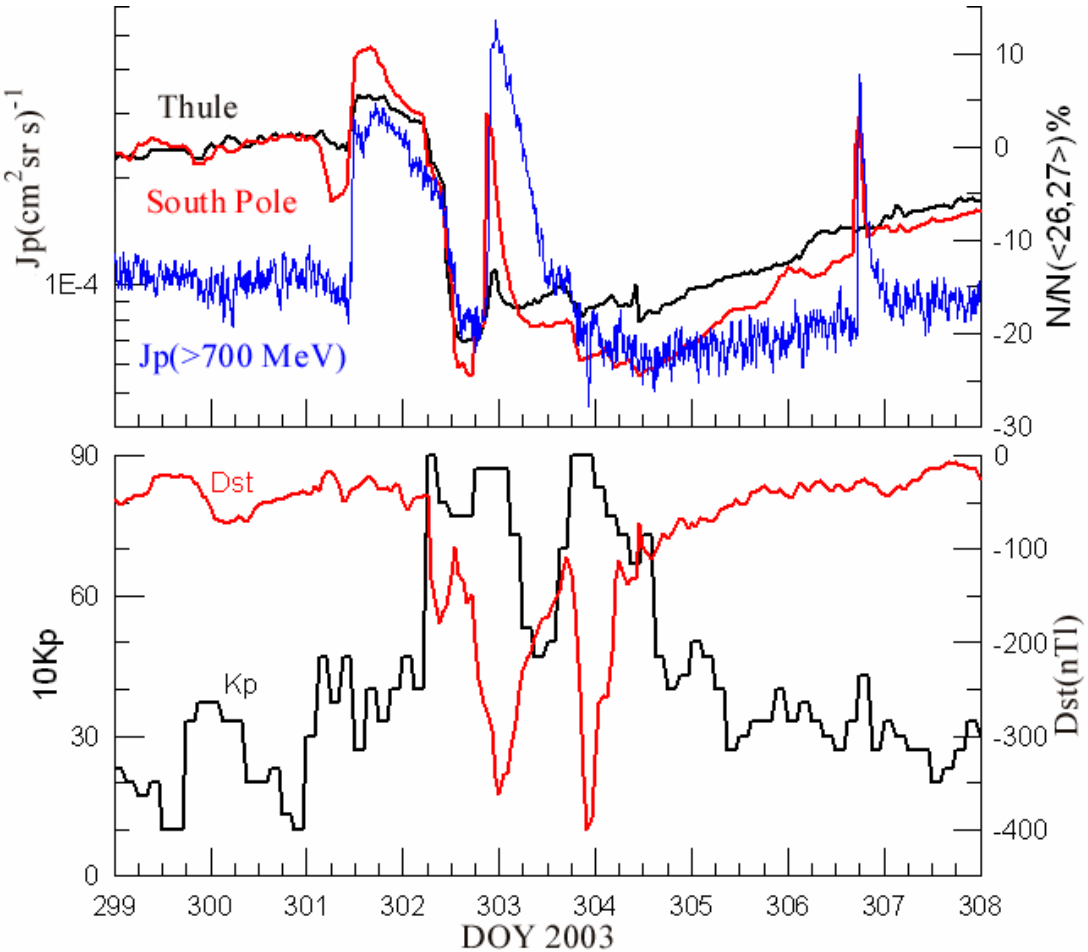
----- Neutron monitor network data at 11.55 UT (Vashenyuk et al.), $E^{-3.5}$

CORONAS-F:

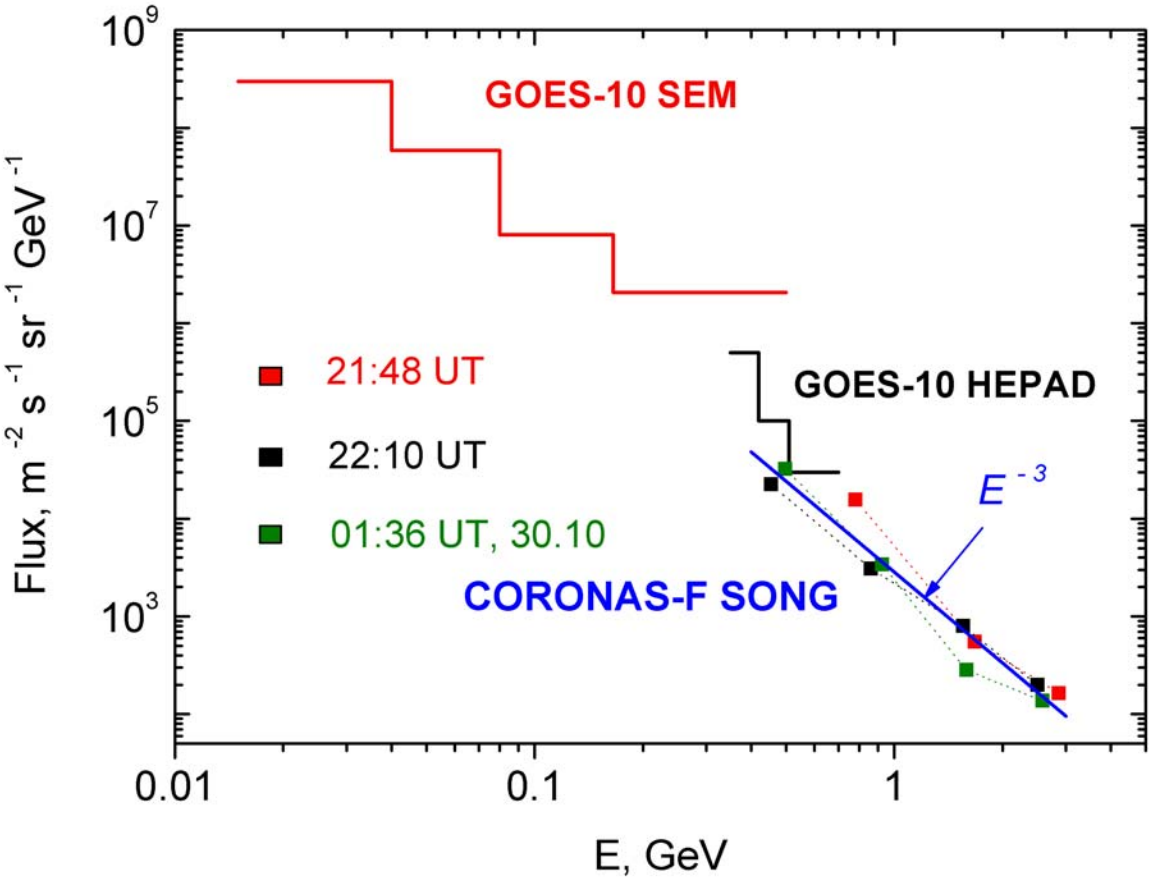
11.44 UT, morning sector

12.04 UT, evening sector

Particle fluxes and geomagnetic conditions



Solar proton spectra on 29 October 2003 (21-24 UT) - PRELIMINARY



Conclusions

1. We have shown that the geomagnetic cut-off effect may be used to observe high-energy solar proton fluxes using satellite data. This approach provides additionally possibilities for solar high-energy particle studying.
2. We measured solar proton spectra in the 0.5 - 3 GeV range for flares of 28 and 29 October 2003. The latest spectrum was determined for the first time.

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