CORONAS-F.

The “CORONAS-F” satellite, the second one of CORONAS satellite series, launched on July 31, 2001 in Russia into a circular orbit with the altitude 507±21 km and 82.5 degree inclination, provided scientific data during the whole period 2002 - 2003. The satellite is oriented towards the Sun. A complex of instruments measuring predominantly corpuscular energetic emissions from the Sun (SKL, coordinated by Skobeltsyn Institute of Nuclear Physics, Moscow, Russia) is a part of experimental devices. Institute of Experimental Physics, SAS, Košice, Slovakia participated at a device SONG measuring energetic neutrons, gammas and protons. Several tens of events with gamma ray increases due to the solar emissions were identified during the two years period.

The dynamics of cosmic particles with the energies well below those of cosmic rays and well above those of solar wind (from few tens of keV up to several MeV) have been studied by the ***Institute of Experimental Physics, SAS, Košice*** (its Department of Space Physics) in the co-operation with the laboratories in abroad and with P.J. Šafárik University as well as Technical University Košice. In addition, the measurements of secondary cosmic rays observed by ground based methods have been analyzed. The analysis of the data obtained both from the low altitude and high apogee satellites, as well as development and construction of new instruments for the future studies continued in the period of years 2002 and 2003.

Both case and statistical type of studies were done with using the large amount of data by energetic particle instruments DOK-2 on Interball-1,-2, and DOK S on Magion 4 and 5, developed at the Department with cooperation of laboratories in abroad. Comparison with data of US satellite POLAR provided a possibility to study a unique case of ion acceleration at the bow shock to unusual high energies during a space weather event on May 4, 1998, when magnetosphere was strongly compressed. It was suggested that ions are accelerated at the quasi-parallel bow shock to energies as high as 1 MeV and subsequently transported into the magnetospheath during that event. More than 200 cases of energetic ion beams with narrow lines in energy spectrum were observed by DOK-2 on Interball-1 in 1995-1998. These events named as AMI (Almost Monoenergetic Ions) cannot be explained by current models of particle acceleration or escape from the magnetosphere. One hypothesis of the

explanation is suggested as the solar wind ions acceleration in a strong electrostatic field burst within a small region. Multispacecraft studies using also DOK-2 data on Interball-1 were used to describe the motion of the magnetopause due to the variations of interplanetary magnetic field. Statistical study of large amount of upstream ion events by DOK-2 has shown that for the diffusive upstream events observed near the bow shock there is much higher probability of observing high flux of protons for quasi-parallel connections to the model bow shock than for the cases with quasi-perpendicular geometry. This is in accordance with the Fermi acceleration at the shock. While such dependence is clear at low energies (~20-30 keV), it becomes less pronounced with the increasing energy. On the other hand the dependence on geomagnetic activity is increasing with energy. The relative importance of the two possible sources of the seed particles, namely those of solar wind ions and particles leaking from magnetosphere was described up to 300 keV on the large data set. The detailed energy spectra by DOK-2 instruments on Interball-1 and 2 showed many cases of dispersive velocity events. They can be used for remote timing and identification of the place of particle injection during geomagnetic disturbances. The dependence of the dispersive events occurrence on altitude, L and magnetic local time was obtained. A case study by DOK-2 during a small substorm when Interball-1 was near the reconnection point in the central magnetotail region, has shown the strong changes of ion flux anisotropy and fast change of energy spectra when the satellite crossed the neutral sheet. Papers and presentations using the measurements by DOK-2 and DOK-S for physical analysis are in [1,3,13,15,17,25,28,29,30,31,38,39,40,41,42,44,45].

The detailed geographic and geomagnetic (L,B) maps of distribution of gamma ray flux at 500 km were obtained by analysis of SONG device measurement on CORONAS I. Comparison with data from US satellite SAMPEX showed similarities with energetic electron fluxes. Thus the measurements of gamma rays can be one of remote sensing observations of the energetic electron flux in radiation belts within the drift loss cone. Comparison of SONG gamma ray measurements with electron fluxes from AE-8 model was done in.

Data analysis of energetic particle measurements on satellite Active and on MIR orbital station yielded in the distribution of proton spikes near geomagnetic equator at different altitudes, various local times and for various levels of geomagnetic activity. Results using measurements by CORONAS I satellite are in papers or presentations [8,9,10,33].

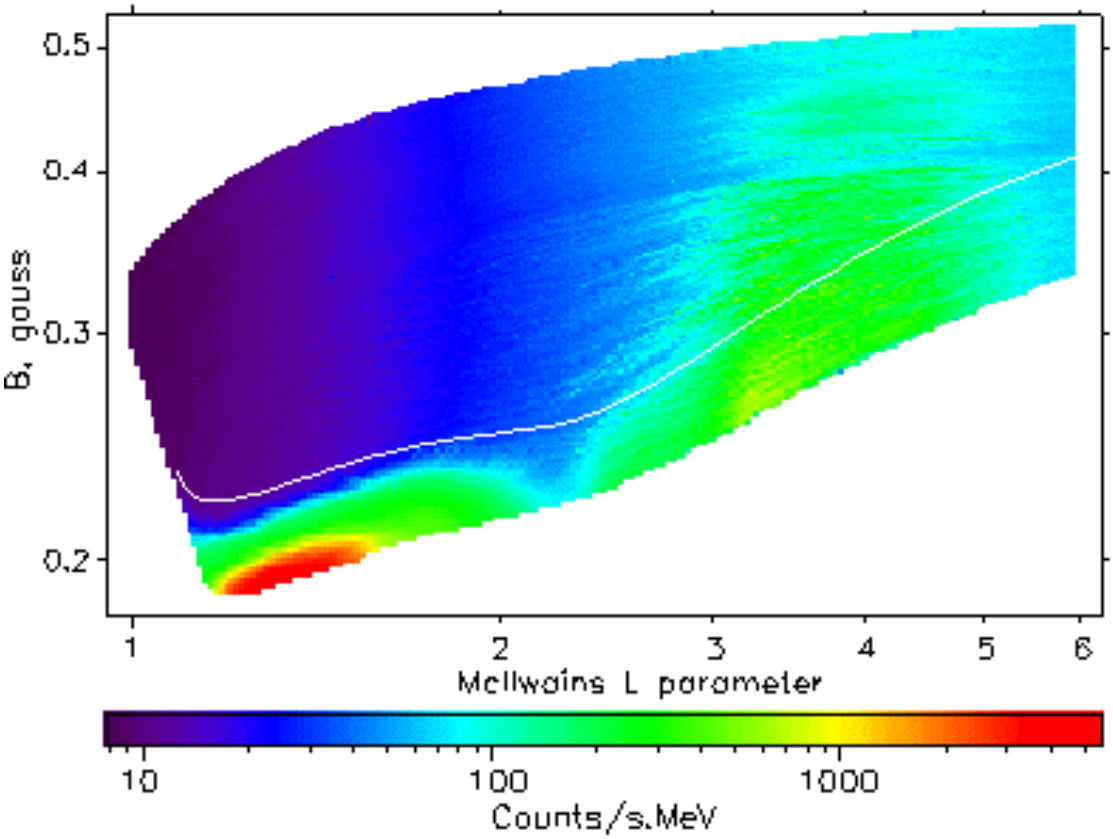

Fig. 1. Gamma ray (3 – 8.3 MeV) flux in LB coordinates obtained from measurements on CORONAS I satellite (altitude ~500 km).

The instrument SONG M measuring the energetic gamma rays and neutrons (its electronic part was designed, constructed and tested in the Department) is working continuously on low altitude polar orbiting satellite CORONAS-F from July 2001 until now. About 40 high energy solar gamma ray emissions were identified from the data in years 2002 and 2003. Results using data from SONG on CORONAS F are in [7,34,35].

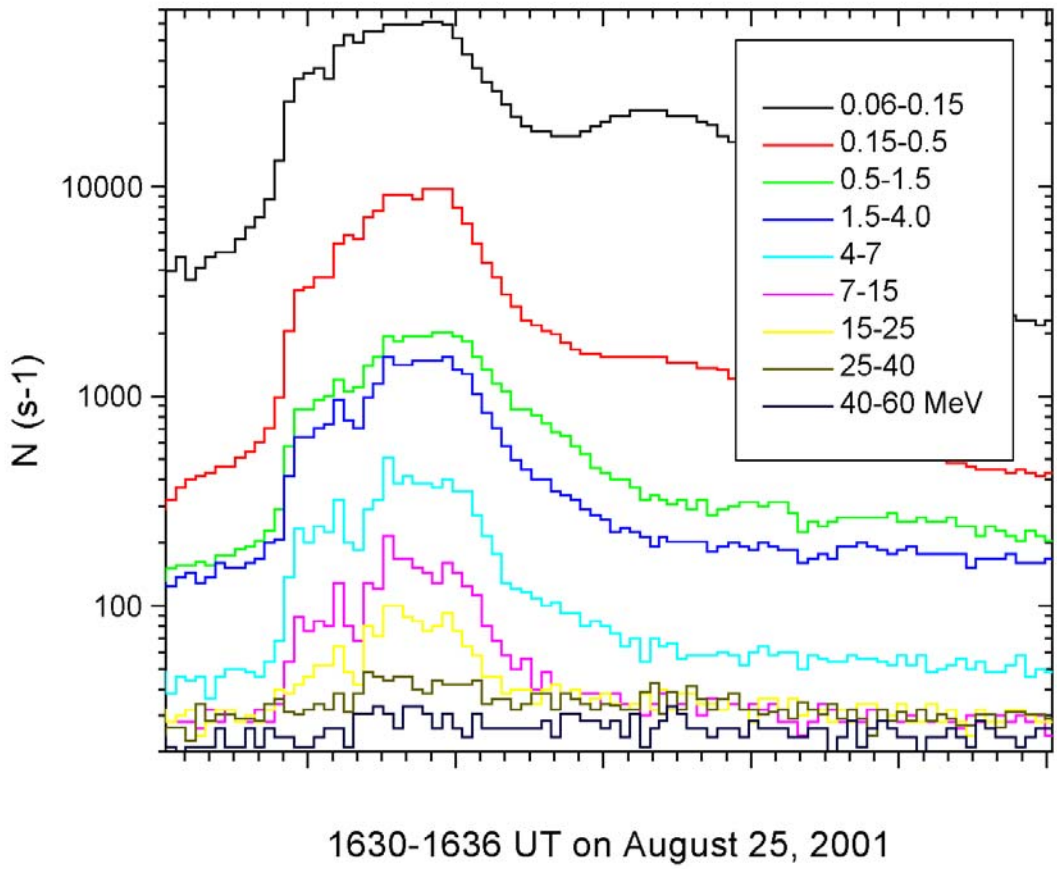

Fig. 2. Example of data obtained from measurements by SONG instrument on CORONAS F satellite. The count rates in different channels are displayed. A strong increase of high energy gamma rays (up to at least 20 MeV) was observed from a solar flare on August 25, 2001. SONG experiment observed also increase due to solar neutrons from that flare.

The institute is continuing the works on design, development and testing of new instruments for the satellite measurements. A photostimulation method was suggested and developed for study of pile-up and dead time effects important for measurements of particle fluxes and energy spectra by solid state detectors in space [2]. The dependence of the registered spectral distortion and the dead time loss on the incident count rate can be observed and recorded clearly with the method. In cooperation with U. of Maynooth, Ireland and STIL Ireland the Electrical Supporting System for the mission ESA-ROSETTA was constructed with the contribution of the Department. In the same cooperation the Department is currently contributing to the design, testing and construction of the Ireland's national instrument NUADU (NeUtral Atom Detector Unit) for

China's Double Star Polar Mission (Principal Investigator Susan McKenna-Lawlor) for the polar mission of the project (joint project of ESA and Chinese Acad. Sci.). The objectives are oriented to processes controlling the ring current characteristics and monitoring of space weather effects in the magnetosphere. The energetic neutral atoms created by charge exchange of energetic ions with the neutrals of exosphere will be observed by a set of 16 solid state detectors regularly spaced over elevation of 180^{o} remotely from the orbit of the satellite.

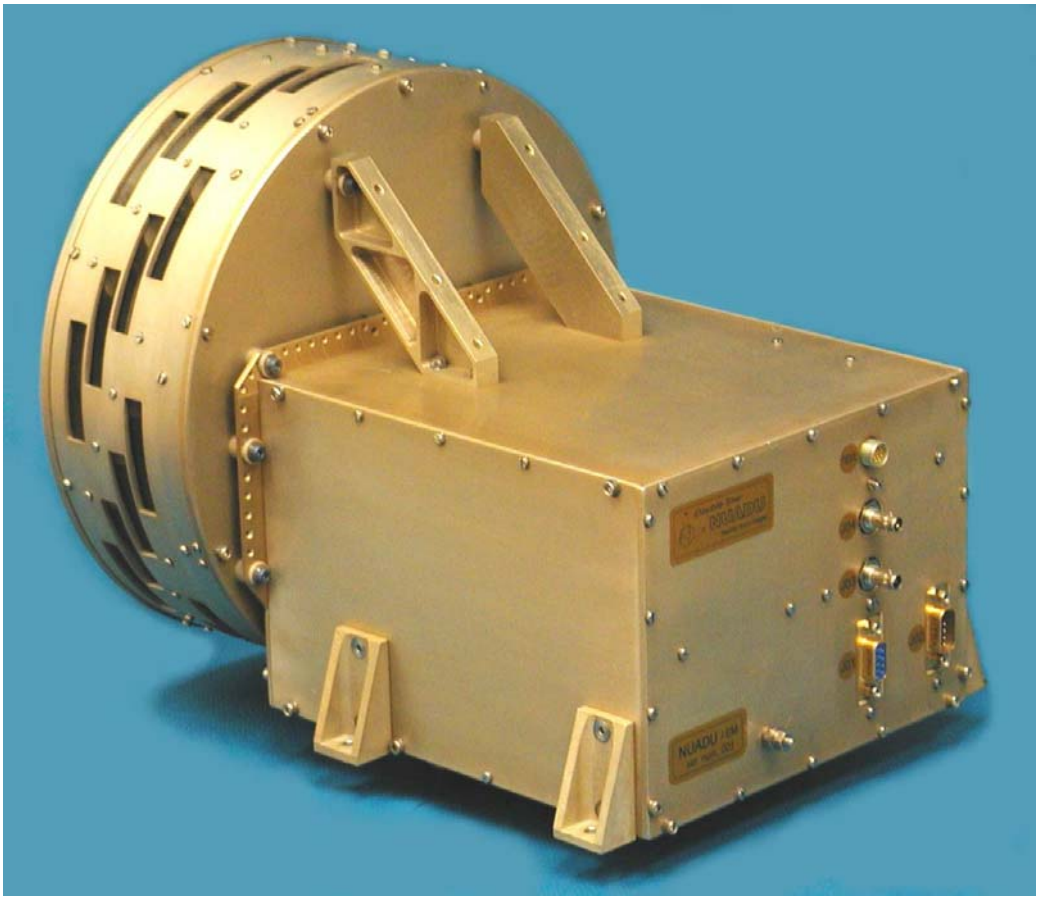

Fig. 3. Ireland's national instrument NUADU (NeUtral Atom Detector Unit) for China's Double Star Polar Mission (Principal Investigator Susan McKenna-Lawlor). Launch is scheduled for July 2004. IEP SAS participated in the development and construction of this experiment.

Data from cosmic ray continuous measurements by neutron monitor at Lomnický Štít with 1 min resolution are now available in real time at http://neutronmonitor.ta3.sk. The modulation of cosmic rays in the heliosphere and sensitivity of neutron monitor to galactic cosmic rays was studied. Connections between cosmic rays, solar variability and space weather effects, as well as temporal evolution of quasiperiodicities in cosmic ray records were examined in the series of papers [11,14,18,19,20,22,23,24,27,31,37,40, 41,42,43]. The geomagnetic effects on cosmic rays have been checked by methods of trajectory computations in model geomagnetic field [4,5,16,26].

References.

1. Anagnostopoulos, G.C., E.T. Sarris, K. Kudela and M. Vandas, Simultaneous spectral variations of energetic ions in the nightside magnetosphere and upstream from the bow shock, *Adv. Space Res*., Vol. 30, No 10, pp. 2253-2258, 2002

2. Baláž, J., A photostimulation method for the study of pile-up and dead time effects in nuclear devices equipped with solid state detectors, *Nucl. Instr. Meth. in Phys. Res.* A 481, p. 323-329, 2002

3. Blecki J, Savin S, Rothkaehl H, Stasiewicz K, Wronowski R, Němeček Z, Šafránková J, Kudela K, The role of wave-particle interactions in the dynamics of plasma in the polar cusp, *Cosmic Res.,* 41 (4): 332-339, 2003

4. Bobik P, Storini M, Kudela K, Cordaro E. G, Cosmic-ray transparency for a medium-latitude observatory, *Nuovo Cimento C*, 26 (2): 177-189, 2003

5. Bobik, P., M. Boschini, M. Gervasi, D. Grandi, K. Kudela, E. Micelotta, P.G. Rancoita, Cosmic ray spectrum at 1 AU: a transmission function approach to the magnetosphere, *Proceedings ESA SP-535*, p. 633-636, ISCS 2003

6. Bobik, P., M.Gervasi, D. Grandi, P.G. Rancoita, I.G. Usoskin, 2D stochastic simulation model of cosmic ray modulation: Comparison with experimental data, *Proceedings ESA SP-533*, p. 637-640, ISCS 2003

7. Bogomolov A.V., Ignat'ev A.P., Kudela K., Kuznetsov S.N., Logachev Y.I., Morozov O.V., Myagkova I.N., Oparin S.N., Pertsov A.A., Svertilov S.I., Yushkov B.Y., Parameters of the intense X-ray and gamma-ray radiation from the solar flare of May 20, 2002; as observed from the Coronas-F spacecraft, *Astron. Lett*., 29 (3): 199-204, 2003

8. Bučík R, Kudela K, Dmitriev A.V, Kuznetsov S.N., Myagkova I.N., Ryumin S.P., Spatial distribution of low energy gamma-rays associated with trapped particles, *Adv. Space Res*., 30 (12): 2843-2848 2002

9. Bučík R, Kudela K, On mass in 4 pi solid angle around SONG CsI scintillator aboard CORONAS-I satellite, *Acta Physica Slovaca*, 53 (4): 329-345, 2003

10. Bučík, R., Kudela, K., Kuznetsov, S.N., Myagkova, I.N., Ryumin, S.P., Review of electron fluxes within the local drift loss cone: measurements on CORONAS-I satellite, *Adv. Space Res*., accepted 2003

11. Fedorov, Yu., M. Stehlík, K. Kudela, J. Kaššovicová, Non-diffusive particle pulse transport: Application to an anisotropic solar GLE, *Sol. Phys*., vol. 208, p. 325-334, 2002

12. Grachev E, Grigoryan O, Juchniewicz J, Klimov S, Kudela K, Petrov A, Štetiarová J, Low energy protons on L <= 1.15 in 500-1500 km range, *Adv. Space Res*., 30 (7): 1841-1845 2002

13. Chang SW, Scudder JD, Kudela K, Spence HE, Fennell JF, Lepping RP, Lin RP, Russell CT, Reply to comment on "MeV magnetosheath ions energized at the bow shock" by J. Chen, T. A. Fritz, and R. B. Sheldon, *J. Geophys. Res*., A 108 (A8): art. no. 1312, 2003

14. Kudela K., Bingsen Xue , Guiming Le , Juan Miao , G. Andrejková , Geomagnetic activity onset predictions: problems with possible signatures in cosmic rays, *Proceedings ESA SP-535*, p. 575-578, ISCS 2003

15. Kecskeméty Károly, Karel Kudela, Susan McKenna-Lawlor , Characteristics of upstream particle fluxes near and far from the Earth s bow shock, *Proceedings ESA SP-535*, p. 667-670, ISCS 2003

16. Kaššovicová, J., K. Kudela, Cosmic Ray Geomagnetic cutoff computations: influence of selected parameters on the result, *Acta Electrotechnica et Informatica,* 2, p.135-136, 2002

17. Klimov SI, Grushin VA, Lissakov YV, Nozdrachev MN, Petrukovich AA, Grachev EA, Grigoryan OR, Lysakov DS, Schwingenschuh K, Auster HU, Fornacon KH, Rustenbach J, Korepanov VE, Juchniewicz J, Afanasjev YV, Kudela K, Interball-1 and MIR orbital station coordinated magnetic field and energetic particles measurements, *Adv. Space Res*., 30 (7): 1847-1853 2002

18. Kozlov Valery, Karel Kudela, Sergei Starodubtsev,Alexey Turpanov, Ilya Usoskin, Victor Yanke, Neutron monitor data base in real time, *Proceedings ESA SP-535*, p. 675-678, ISCS 2003

19. Kozlov, V., L. Ksenofontov, K. Kudela, S. Starodubtsev, A. Turpanov, I. Usoskin, V. Yanke, Real-time Cosmic Ray Database (RECORD), *28th International Cosmic Ray Conference, Tsukuba*, JP, Universal Academy Press, Inc., ed. T. Kajita et al, p. 3473-3476, 2003

20. Kudela, K., and M. Storini, Direct and Indirect Relations of Cosmic Rays to Space Weather, Proc. SOLSPA, the Second Solar Cycle and Space Weather Euroconference Vico Equense, Italy, *ESA SP-477*, p. 289-292, 2002

21. Kudela, K., Baláž, J., Strhársky, I., Energetic particle monitoring in space: three decades of experience at IEP SAS, in *RAST2003, Proc. of the International Conference on Recent Advances in Space Technologies*, November 20-22, 2003, Istanbul, Turkey, ed. S. Kurnaz, F.Ince, S.Onbasioglu, p. 173-178, 2003

22. Kudela, K., Energetic particles in space: relations to space weather and influence on the atmosphere, *Acta Electrotechnica et Informatica,* 2, p.137-143, 2002

23. Kudela, K., J. Rybák, A. Antalová, and M. Storini, Time evolution of low-frequency periodicities in cosmic ray intensity, *Solar Physics*, 205, p. 165-175, 2002

24. Kudela, K., M. Storini, Cosmic ray variability around the geomagnetic disturbances, *28th International Cosmic Ray Conference*, Tsukuba, JP, Universal Academy Press, Inc., ed. T. Kajita et al, p. 3589-3592, 2003

25. Kudela, K., Sibeck, D.G.,Slivka M., Lutsenko V., Gretchko T., Sarris E.T., High Energy Particle Dispersion Events Observed by Interball-1 and –2, *Adv. Space Res*., 30 (12): 2849-2854 2002

26. Kudela, K., Usoskin, I.G., On magnetospheric transmissivity of cosmic rays, *Czech. J. Phys. B*., accepted, 2003

27. Kudela, K., V. Rušin, M. Rybanský, M. Minarovjech, and R. Langer, Solar and Cosmic Ray Measurements at Lomnický Štít, in *Proc. of the Workshop on Atmospheric Research at the Jungfraujoch and in the Alps*, Davos, Switzerland, Sept. 20, 2002, p. 31-32, 2002

28. Kudela, K., V.N. Lutsenko, D.G. Sibeck and M. Slivka, Energetic ions upstream of the Earth's bow shock: Interball-1 survey, *Adv. Space Res*., vol. 30, No 12, p. 2731-2736, 2002

29. Kudela, K., V.N. Lutsenko, D.G. Sibeck, and M. Slivka, Energetic ions and electrons within the magnetosheath and upstream of the bow shock: Interball-1 overview, *Adv. Space Res*., vol. 30, No 7, p. 1685-1692, 2002

30. Kudela, K., V.N. Lutsenko, D.G. Sibeck, M. Slivka, T.V. Gretchko and E.T. Sarris: High energy particle dispersion events observed by Interball-1 and – 2, *Adv. Space Res*., vol. 30, No. 12, p. 2849-2854, 2002

31. Kurilchik, V., V. Prokudina, K. Kudela, M. Slivka, The study of relations between kilometric radiobursts and energetic electrons during powerful solar flares: INTERBALL-1, Proceedings *ESA SP-535*, 679-682, ISCS 2003

32. Kuznetsov SN, Bogomolov AV, Denisov YI, Kordylewski Z, Kudela K, Kurt VG, Lisin DV, Myagkova IN, Podorol'skii AN, Podosenova TB, Svertilov SI, Sylwester J, Stepanov AI, Yushkov BY, The solar flare of November 4, 2001, and its manifestations in energetic particles from Coronas-F data, *Solar System Res*., 37 (2): 121-127, 2003

33. Kuznetsov, S.N., I.N. Myagkova, S.P. Ryumin, K. Kudela, R. Bučík, H. Mavromichalaki, Effects of the April 1994 Forbush events on the fluxes of the energetic charged particles measured on board CORONAS-I satellite: their connection with conditions in the interplanetary medium, *Journal of Atmospheric and Solar-Terrestrial Physics*, Volume 64, Issues 5-6, s.535-539, 2002

34. Kuznetsov, S.N., K. Kudela, I.N. Myagkova, B.Yu. Yushkov, Gamma and X-ray solar flare emissions: CORONAS-F measurements, *28th International Cosmic Ray Conference, Tsukuba*, JP, Universal Academy Press, Inc., ed. T. Kajita et al, p. 3183-3186, 2003

35. Kuznetsov, S.N., Myagkova, I.N., Yushkov, B. Y., Kudela, K., X ray and gamma ray emission solar flare catalogue obtained by SONG on board CORONAS-F satellite, Proceedings *ESA SP-535*, p. 683-686, ISCS 2003

36. Kuznetsov, S. N., K. Kudela, S.P. Ryumin, Y.V. Gotselyuk, Coronas F satellite: Tasks for study of particle acceleration, *Adv. Space Res.,* 30, No 7, pp. 1857-1863, 2002

37. Laštovička J, Križan P, Kudela K, Cosmic rays and total ozone at higher middle latitudes, *Adv. Space Res*., 31 (9): 2139-2144, 2003

38. Lutsenko, V.N., T.V. Gretchko, A.V. Kobelev, and K. Kudela, Dispersion structures in the energetic ion and electron spectra in the auroral region: their nature, properties and implication, *Adv. Space Res*., vol. 30, No 7, pp. 1787-1793, 2002

39. Lutsenko, V.N., T.V. Gretchko, A.V. Kobelev, V.A. Styazhkin, and K. Kudela, Wavy energetic ion dispersion events and Pc-5 type magnetic field pulsations in auroral zones, *Adv. Space Res*., vol. 30, No 7, pp. 1783-1786, 2002

40. McKenna-Lawlor S, Kudela K, Kecskemety K, Chang SW, Spacecraft measurements of ions and electrons (> 40 keV) near and far upstream of the Earth's bow shock, *Adv. Space Res*., 31 (4): 933-938 2003

41. McKenna-Lawlor, S.M.P., M. Dryer, Z. Smith, K. Kecskeméty, C.D. Fry, W. Sun, C.S. Deehr, D. Berdichevsky, K. Kudela, and G. Zastenker, Arrival times of Flare/Halo CME associated shocks at the Earth: comparison of the predictions of three numerical models with these observations, *Annales Geophysicae*, vol. 20, p. 917-935, 2002

42. McKenna-Lawlor, S.M.P., M. Dryer, Z. Smith, K. Kecskeméty, C.D. Fry, W. Sun, C.S. Deehr, D. Berdichevsky, K. Kudela, and G. Zastenker, Comparison between the measured arrival times at L1 of shocks generated in association with eleven flare/halo CME events and their predicted arrival times using three numerical models, Proc. SOLSPA, the Second Solar Cycle and Space Weather Euroconference Vico Equense, Italy, *ESA SP-477*, p. 285-288, 2002

43. Miyasaka, H., K. Kudela, S. Shimoda, Y. Yamada, E. Sakamoto, K. Munakata, T. Yuda, Z.H. Tan, J.L. Zhang, Y.Q. Tang, H. Lu, H.B. Lu, Labaciren, X.R. Meng, A.F. Yuan, Geomagnetic Cutoff Variation Observed with TIBET Neutron Monitor, *28th International Cosmic Ray Conference, Tsukuba,* JP, Universal Academy Press, Inc., ed. T. Kajita et al, p. 3609-3612, 2003

44. Slivka M., K.Kudela , Proton fluxes measured in the plasma sheet during December 3, 1996 substorm growth phase, *Acta Electrotechnica et Informatica*, 2, p.152, 2002

45. Slivka, M. and K. Kudela, Proton fluxes in the neutral sheet: a case study by the DOK2 on Interball-1, *Czech. J. Phys.,* vol. 52, No 12, p. 1357-1369, 2002

46. Spurný, F., Ts. Datchev, and K. Kudela, Increase of the onboard Aircraft Exposure during a Solar Flare and its Quality Change, *Nuclear Energy Safety*, 11, 49, 103-107, 2003

47. Storini, M., S. Massetti, K. Kudela, J. Rybák, On the shape of cosmic ray modulation during even and odd-numbered solar activity cycles, *28th International Cosmic Ray Conference, Tsukuba*, JP, Universal Academy Press, Inc., ed. T. Kajita et al, p. 4095-4098, 2003