East Eur. J. Phys. Vol.1 No.3 (2014) 95-103

PACS: 28.50Ma, 61.20ja

DEFINITION OF CONTRIBUTION AND TYPE OF PARTICLES IN MIXED SIGNAL DETECTORS

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Received September 25, 2014

Procedure of particle type definition in mixed signal detectors was developed by the results of the device operation simulation and by the results of experimental processing of telemetry data arriving from the orbit. The procedure is based on calculation justification of predominately electron signal in the electron detection channel, lack of electron and gamma signals in the mode of measuring protons in the energy range of 7.4-10.0 MeV, possibility to study the device operation in the range of an authentic proton flux when an electronic component is absent. The latter case allowed to confirm record of bremsstrahlung in the mode of high energy particle detection using the device when the satellite passed through the Brazilian magnetic anomaly (BMA). Basing on the characteristic properties of the electron and proton channels, an attempt was made to define the type of particles in the background fluxes. The simulation was performed using GEANT 4.7 package intended for designing nuclear processes of high-energy charged particles passage through the satellite spectrometer-telescope STEP-F. The programs were developed using C ++ and they work under control of OS RadHat LINUX 6.2 .

KEY WORDS: recording channel, silicon matrix, radiation belt, background fluxes, flux correlation, time/space distribution

ВИЗНАЧЕННЯ ВНЕСКУ ТА ТИПУ ЧАСТОК У ДЕТЕКТОРАХ ЗІ ЗМІШАНИМИ СИГНАЛАМИ

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Розроблена методика визначення типу часток у детекторах зі змішаними сигналами з результатів моделювання роботи прибору та даних експериментальної обробки телеметричної інформації отриманою з орбіти. В основу методу покладено розрахункове обгрунтування переважно електронного сигналу з каналу електронного детектування, брак електронного та гама-сигналу у режимі вимірювання протонів у діапазоні енергій 7.4-10.0 МеВ, можливість досліджувати роботу обладнання у області достовірного потоку протонів та одночасно відсутністю електронної компоненти. Останній випадок дозволив підтвердити реєстрацію гальмового випромінювання у режимі детектування приладом часток високої енергії при проходженні супутником Бразильської магнітної аномалії . Виходячи з особливості роботи електронного та протонного каналів, зроблена спроба визначення типу часток у фонових потоках. Програми моделювання роботи приладу СТЕП-Ф розроблені на мові С++ та працюють на платформі ОС Red Hat LINUX 6.2 FEDORA .

КЛЮЧОВІ СЛОВА: канали реєстрації, кремнієва матриця, радіаційний пояс, фонові потоки, кореляція потоків, часовий/просторовий розподіл

ОПРЕДЕЛЕНИЕ ВКЛАДА И ТИПА ЧАСТИЦ В ДЕТЕКТОРАХ СО СМЕШАННЫМИ СИГНАЛАМИ

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Разработана методика определения типа частиц в детекторах со смешанным сигналом по результатам моделирования работы прибора и данным экспериментальной обработки телеметрической информации поступавшей с орбиты. В основе методики лежит расчётное обоснование преимущественно электронного сигнала по каналу электронного детектирования, отсутствие электронного и гамма сигнала в режиме измерения протонов в диапазоне энергий 7.4-10.0 МэВ, возможность исследовать работу прибора в области достоверного потока протонов при одновременном отсутствии электронной компоненты. Последний случай позволил подтвердить регистрацию тормозного излучения в режиме детектирования прибором частиц высокой энергии при прохождении спутником Бразильской магнитной аномалии . Исходя из особенностей работы электронного и протонного каналов, сделана попытка определения типа частиц в фоновых потоках. Моделирование проводилось с использованием пакета разработчика GEANT 4.7 ядерно-физических процессов прохождения заряженных частиц высокой энергии через спутниковый спектрометр-телескоп СТЭП-Ф. Программы разработаны на языке С++ и работают под управлением ОС RadHat LINUX 6.2 .

КЛЮЧЕВЫЕ СЛОВА: каналы регистрации, кремниевая матрица, радиационный пояс, фоновые потоки, корреляция потоков, временное/пространственное распределение.

The scientific experiment with satellite telescope of electrons and protons STEP-F, as a part of the “CORONA-PHOTON” complex, was carried out in accordance with the agreement between the V.N. Karazin Kharkov National University and the National Research Nuclear University (MIPhI).

The object of the experiment was to study the energy spectra dynamics and pitch-angle distribution of high energy electrons, protons and alpha-particles of the Earth radiation belts during magnetospheric storms and substorms as well as exposure of the Earth magnetosphere to the high speed flows of sun wind.

The device consists of a detector unit (STEP-FD) installed outside the hermetic compartment of the spacecraft and a digital information processing unit STEP-FE placed inside the hermetic compartment.

The telescopic system of the detection head in the STEP-FD detector unit consists of two identical silicon position-sensitive matrix detectors D1 and D2 (each of dimensions 45×45 mm and thickness 380 μm) placed in series, and two scintillation detectors based on Cs(Tl) monocrystals "scanned" by photodiodes of large area (in D3 detector) and by photomultiplier (in D4 detector) [1,2].

The aim of this work was to achieve the correspondence between calculated and measured data by modeling possible spectrum distribution of primary particles.

The simulation was performed using GEANT 4.7 package intended for designing nuclear processes of high-energy charged particles passage through the satellite spectrometer-telescope STEP-F. The programs were developed using C ++ and they work under control of OS RadHat LINUX 6.2 [3].

SIMULATION OF MIXED FLUX RECORDING WITH THE STEP-F DEVICE

When studying the experimental results of STEP-F device operation, some special model calculations were made to determine possible contribution of protons to an electron signal.

Possibility to record ions in the recording channel with 0.18-0.51 MeV electrons (hereinafter – D1e) is determined by energy losses of protons (the lightest ions) with energy from 3.5 MeV. The minimum energy of the protons recorded in the first positional-sensitive matrix, is determined by their maximum path in an aluminum screen with thickness of 105 microns. As soon as a particle with near-threshold energy can leave in D1 (hereinafter – the first silicon positional-sensitive matrix detector) rather small energy, there is a probability to record protons with such energy in channel D1e.

With the aim to estimate the potential contribution of protons in the electron recording channel the absorption probability of proton sub-threshold energy in D1 was calculated. For the proton recording channel calculation was fulfilled in the energy range of 3.7-7.4 MeV, threshold of registration - 500 keV. The calculations were made in the energy range of 3.5-3.7 MeV (Fig.1a, Tab.1).

For the proton energy of 3.68 MeV, the minimum absorbed energy in D1 was 600 keV. Basing on the energy range of protons of 3.51-3.67 MeV which can be recorded in the electron channel (Tab.1), the proton flux in channel D1e, according to the calculations carried out in approximation of the uniform spectral distribution of a proton flux by energies can make 4.3 % from the proton flux recorded in channel D1p. In approximation of exponential distribution of protons by energies (Fig.1b), the proton component contribution to the electron signal can reach 12 % of the proton flux recorded in channel D1p.

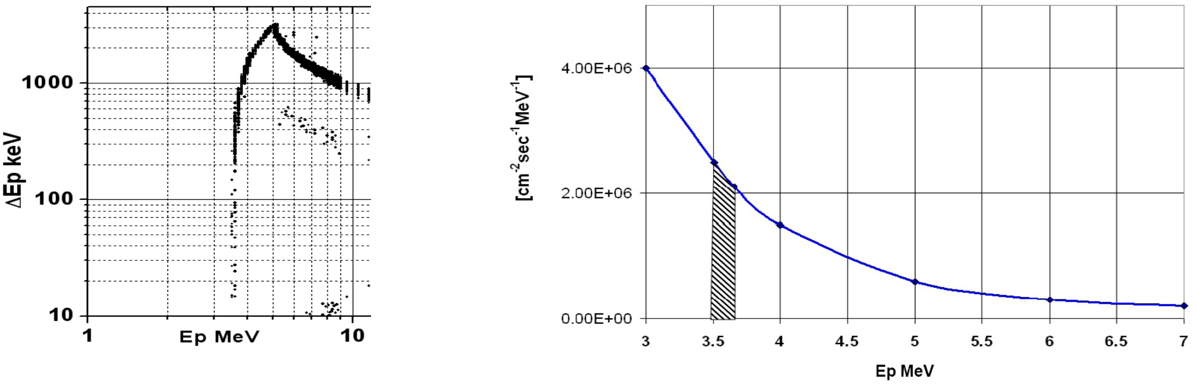

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Fig.1. Effects of simulation of the STEP-F device operation with protons in D1
a – Dependence of the absorbed energy in D1 on the primary energy of the proton (threshold energy = 3.5 MeV);
b – fragment of an exponential spectral distribution of protons [4].

Accordingly, the maximum proton contribution of full signal in channel D1e can make 12% at low level of the electron signal compared with the proton flux. The correlation with the experimental data will be demonstrated below.

Table 1.

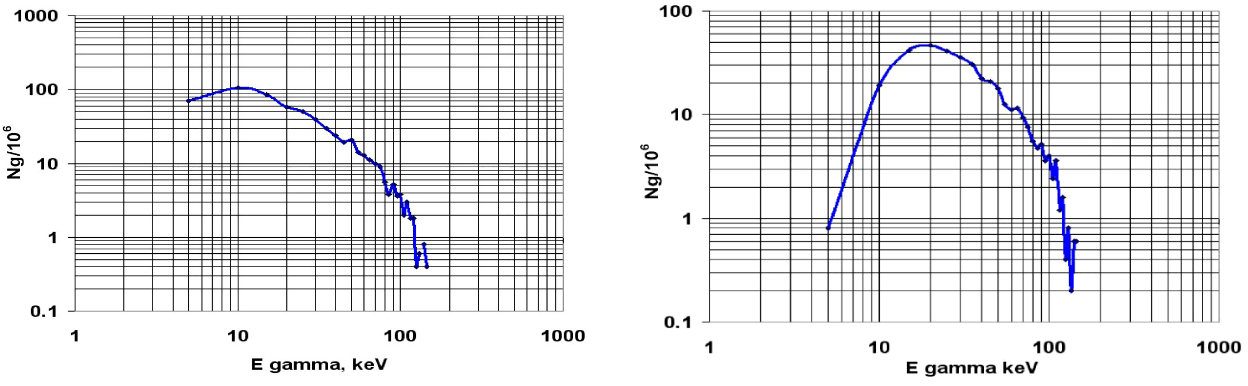
Distribution of potential absorption in the first silicon matrix at energy less than 500 keV.

E_p MeV	3.51	3.58	3.59	3.60	3.61	3.65	3.67
Recording probability in D1e	100 %	100 %	90 %	80 %	70 %	50 %	40 %

Preliminary analysis of the experimental data on the electron fluxes confirms the calculation results [2]. In its turn, after the completion of the analysis of the entire available experimental data array on the protons spectral distribution, the calculated values of the protons contribution to the electron channel will be specified.

Low energy of the device threshold in the mode of recording electrons can result in recording X-rays and gamma-quanta. One of the X-ray sources effecting on the device are electron fluxes with energies of up to 170 keV. Electrons in this energy range do not get to the detector, being absorbed by the input aluminum window with thickness of 105 μm and by collimator of the STEP-F device. The value of this flux can exceed the values of the electron flux in the energy range that is recorded by D1e by almost a factor of ten (see experimental part of article).

Model calculations of bremsstrahlung generation in the protective window, and in the STEP-F device input collimator, as well as this bremsstrahlung record by silicon matrixes were carried out. Fig.2 presents spectral distribution of gamma-quanta getting to the first detecting matrix (Fig.2a) and to the second silicon positional-sensitive matrix (hereinafter – D2) (Fig.2b).



a b

Fig. 2. Bremsstrahlung spectra getting on D1 – a, and D2 – b, when the device is irradiated with monochromatic electron flux with energy of 150 keV for electron beam $N_e=10^6$

As Fig.2 shows, the bremsstrahlung spectrum getting to D1 is essentially softer than that getting to D2, so its intensity is also more essential. Calculations showed that besides the secondary gamma rays getting in D1, about 2% of the primary electrons with energy of up to 150 keV get there too, what can also make its contribution to D1 detector reading, at essential values of fluxes in the range of low energies of electrons. As to the detecting matrix D2, electrons in this range of energies virtually do not get there. The results of the device operation simulation have also shown that the signal from the gamma-quanta, recorded in D1, is nearly by a factor of a hundred stronger than the signal in D2. So irradiation of the detector silicon matrixes with gamma-quanta from the input window transmits a signal practically only to D1. Radiation yield from the aluminum foil, as well as from the input collimator of STEP-F device for the primary electron energy of 150 keV was $2.028e^{-3}$ per one electron [5].

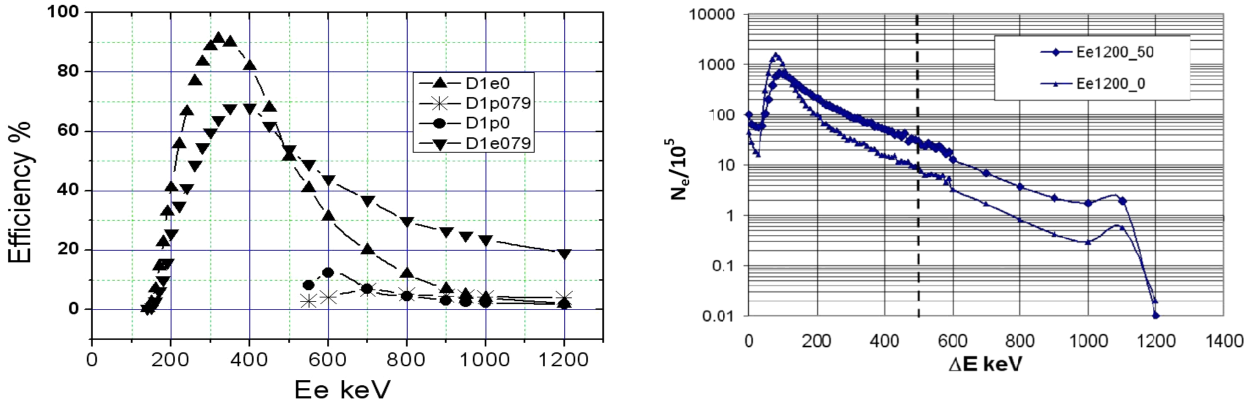
In case of the electron flux excess in this energy range by a factor of a hundred compared to the electron flux which is recorded in the D1e channel, the extra particle flux can rise to 20% due to bremsstrahlung. Model calculations showed that in the energy range of gamma rays from 50 to 200 keV at bremsstrahlung generation on the side of the input window, the Compton scattering signal in D1 can add up to 1.5% of the total particles flux recorded by the detector. The bremsstrahlung generated by the electron flux incident on the device on the side of the input window and the collimator can provide an effective contribution to the reading of D1 within the limits of 1% over the entire energy range.

To estimate the share of the electron component of the particle flux recorded in the mixed radiation channel $p(E_p$ .7-7.4 MeV) + $e(E_e$=0.55-0.95 MeV), hereinafter D1p, simulation of the STEP-F device response to the real electron fluxes obtained under the CORONAS-PHOTON experiment was carried out.

The model is developed in the approximation of the continuity of spectral distribution of the primary electron flux and isotropic nature of the primary electron angular distribution.

Before calculating the integral components of the recorded flux for each energy of spectral distribution of the primary electrons recorded by the detecting matrices, calculations of the electrons absorption probability distribution between the matrix detectors D1 and D2 when irradiating the STEP-F device by electrons both at normal angle of incidence to the surface of the protective foil and when irradiating the device by electron flux with isotropic angular distribution were performed (Fig.3). Figure 3a presents the calculation results for the electron detection efficiency in channels D1e and D1p both for the case of normal incidence of the primary electron flux, and for the case of isotropic distribution of that in the range of angles corresponding to the STEP-F device apertures. The dependence of the number of interacted electrons on their energy loss in the silicon matrix was calculated for each primary electron energy (Fig.3b). The calculation was performed as follows: for each electron energy a flux with known angular distribution was simulated and in accordance with the pre-selected power range, the events with the same energy loss were summed. To calculate the detection efficiency in the channel D1p the obtained curves were integrated, starting with the threshold energy for D1p channel (Fig.3b).Detection efficiency in D1e channel was calculated as the ratio of the particle flux recorded in D1 and not caught by the second silicon matrix to the particle flux incident on the protective foil.

When simulating electron angular distribution corresponding to STEP-F device aperture essential decrease in efficiency of low energy electron recording was observed as compared to simulation of normal angle of incidence, but in this case the absorption probability of electrons with energies exceeding the range of the electron detection in channel D1e – 0.18-0.51 MeV increased (Fig.3). Recording of electrons in channel D1p is due to the fact that for the high-energy electrons a certain probability of their complete absorption always exists. As is evident from Fig.3, when electrons are incident at wide angle the absorption probability for high-energy electrons also increases (Fig.3a,b).



a b

Fig.3. Sensitivity of D1 detector when recording primary electron flux in D1e and D1p channels
a: ▲ – D1e at normal angle of incidence; ж – at irradiation angles in the range of 0 - 79 °; ● and ▼ – the same for D1p channel.
b: ▲ – distribution of energy loss of monochromatic electron flux in D1 detector of SETEP-F device, $N_e = 10^5$, $E_e = 1.2$ MeV at normal angle of incidence; ♦ – at angle of 50 °; vertical dashed line – threshold of D1p recording channel.

Calculations have shown that the most part of the flux in the energy range recorded in channel D1p, is recorded in the channel for electrons with energy ranging from 0.35 to 0.95 MeV, hereinafter – D2e (Tab.1). It should be noted that electrons of this energy range are also recorded in channel D1e (Fig.3a), but as is clear from the Figure, low-energy electrons predominate considerably in the recording channel D1e, what makes it difficult to obtain a stable correlation between the fluxes in channels D1e and D1p despite their identical geometric factors.

Table 2.

Probability of electron recording in channels D1p and D2e

Primary electron energy keV	Recording efficiency in D1p channel %	Recording efficiency in D1p channel %
550	2.8	48
700	6.6	81
800	5.2	89
900	4.5	79
1200	3.9	38

Possible distinction of the electron primary flux distribution in different recording channels can be both spectral distribution of a primary flux, and the character of primary angular distribution. Simulation of hitting of the electron fluxes to the device recording surface at different angels was carried out. For example, when irradiating the device with the wide-angle beam of 53°, the ratio of recorded fluxes D1p/D2e for $E_e = 1200$ keV increased twice as compared to the data obtained at isotropic irradiation of the STEP-F device.

Calculation of primary electron spectral distribution was simulated using the following power function:

$$N(E) = \left(\frac{E_{\min}}{E} \right)^b , \tag{1}$$

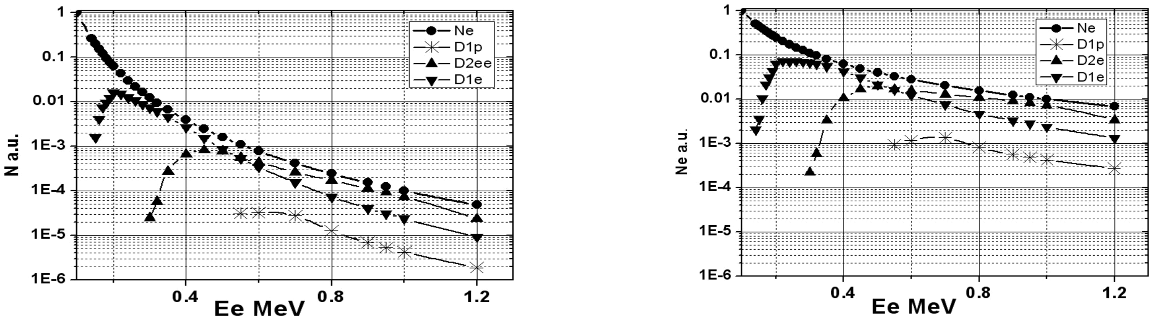
where parameter b > 0, $E_{\min}$ – the minimal energy in the spectrum.

Such algorithmization well corresponds to the characteristic distribution of electrons incident on satellite (see the part of comparison with another data sources). Parameter b was chosen so as to get real relation between the fluxes of electrons detected by the detecting silicon matrix (hereinafter referred to as D1 and D2) for the whole analyzable period of the satellite operation.

The electron flux recorded by each matrix was calculated as the integral of the product of spectral distribution of the electron primary flux and electron absorption probabilities in each recording channel within the whole energy range of each matrix allowing for the isotropic angular distribution (Fig.4).

Variation of spectral distribution using power function showed no significant spectral dependence for the electron flux absorbed in D1p channel. Part of the electron flux recorded in the mixed channel (D1p) ranged from 4% to 5.5% of the electron flux detected in D2e channel, at changing of the flux ratio D1e/D2e from 9 to 2, what corresponds to the variation of parameter b from 4 to 2 ((1) and Fig.4).

Variation of angular distributions (predominance of wide or lack of small angles) has shown potential growth of ratio for fluxes D1p/D2e irrespective of the dependence on the primary spectral distribution of the electron flux.



a b

Fig.4. Simulation of recorded flux distribution in electron recording channels

● – a primary flux; ▼ – the flux recorded in D1e; ▲ – the flux recorded in D2e; ж – the flux recorded in channel D1p.
In a – parameter b = 4; In b – parameter b = 2.

PROTON COMPONENT SELECTION IN THE MIXED RECORDING CHANNEL D1p DATA FROM STEP-F DEVICE

At "Coronas-photon" satellite passage through radiation belts, spatial distributions of the fluxes recorded in channels D2e and D1p, practically coincide, but the intensity recorded in channel D1p, is essentially lower than that in D2e (Fig.5).

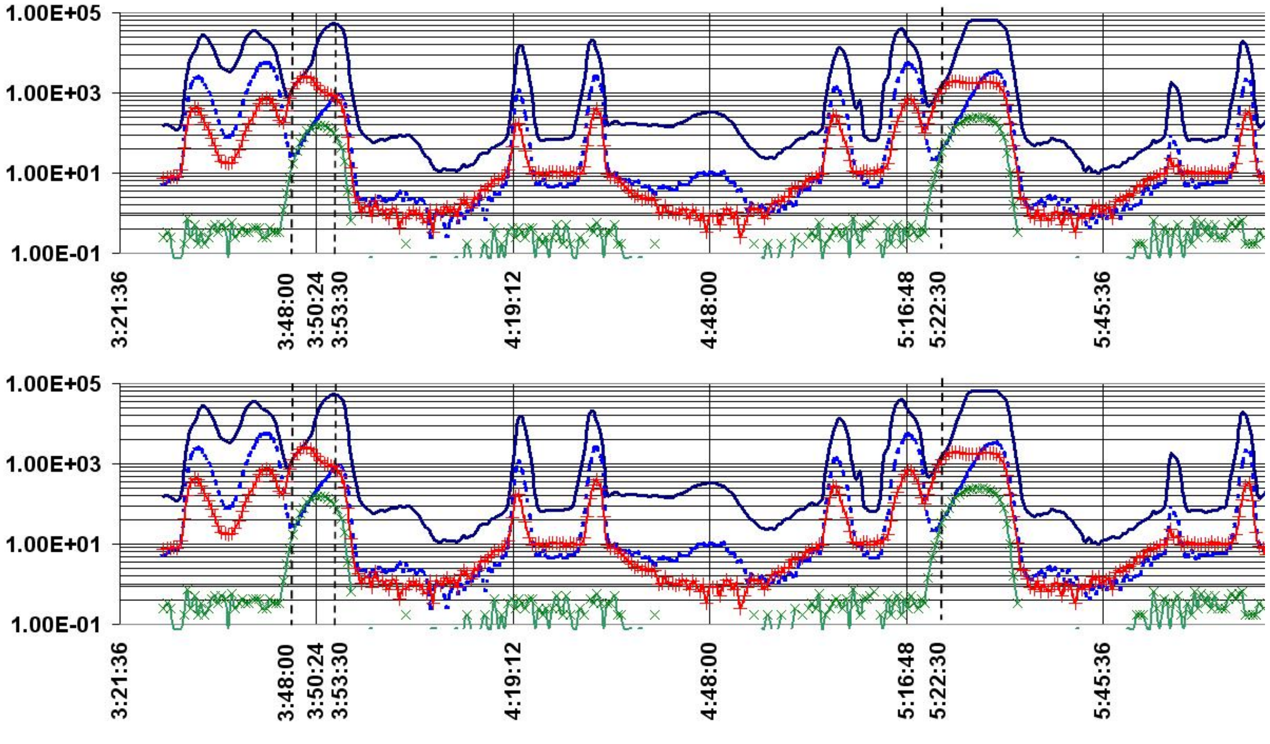


Fig.5. Temporal (spatial) distribution of particle fluxes recorded in channels D1e – the upper curve, D2e – the dashed curve, D1p – mark +, D2p – mark **×.**

Figure 5 shows how spatial distribution of the fluxes recorded by electron channels recur in D1p, an exception is BMA area in which, at least, in its peripheral part, a marked discrepancy between indications of proton and electron channels is observed (at 3:50:24) .

Electron fluxes, when penetrating through detecting matrices, are distributed in recording channels according to the electrons path range, and in case of the mixed recording channel D1p they are selected by the level of the absorbed energy threshold. However, due to the probabilistic character of electron energy loss, as well as high degree of angular scattering dispersion, electrons of the same energy can be recorded in all the channels under study (Fig.4).

As regards to the recording channel D1e, high energies are recorded not due to complete absorption of electrons in D1 (in this case, they are recorded in D1p channel), but due to their missing in the second matrix. Most part of the flux, which can enter the channel D1p, is recorded in D2e channel (Fig.4).

To study correlation of fluxes recorded in different channels and flux detectors, relations between D2e/D1p and D1e/D2e have been analyzed (Fig.6a and 6b, respectively).

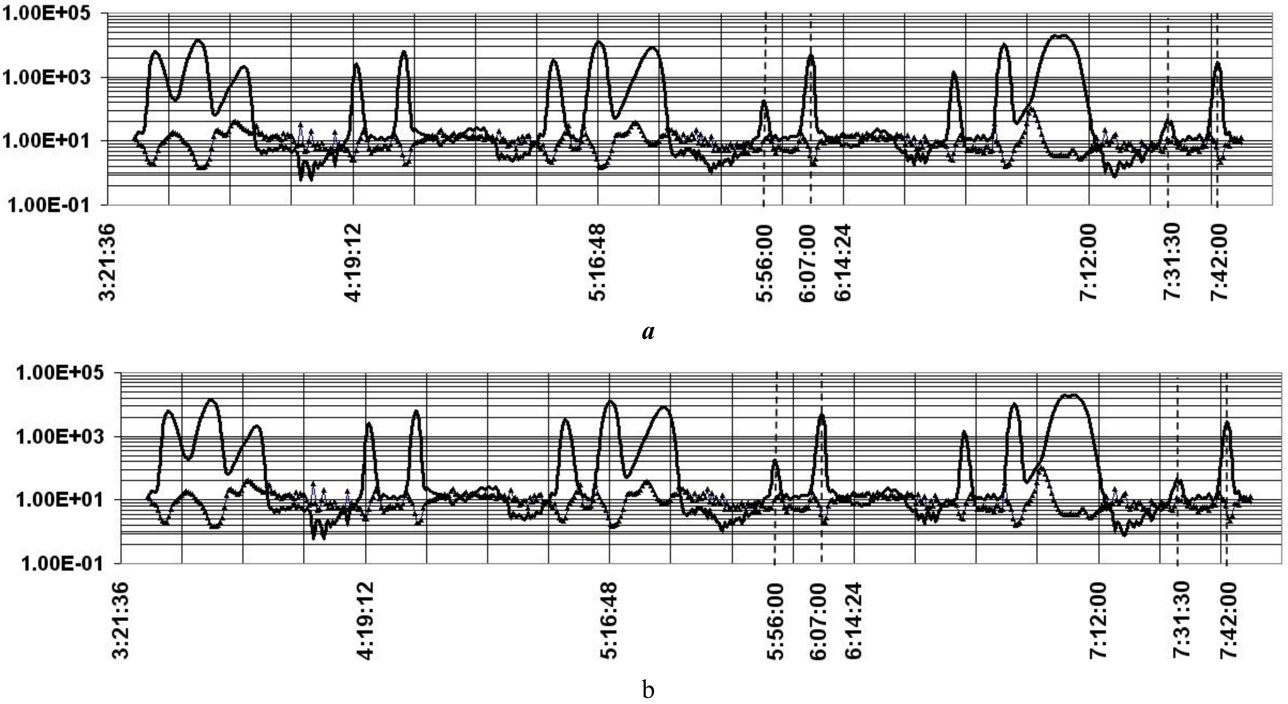


Fig.6. Correlation of particles fluxes recorded in different channels

a: In channels D1p and D2e, D2e – bold curve; relation D2e/D1p – triangle markers;
b: In channels D1e and D2e, D2e – bold curve, ratio D1e/D2e – triangle markers.

Presence of the expressed maximum in the areas corresponding to passage through the radiation belts is characteristic for curve D2e/D1p. This maximum correlates with D2e/D1p ratio which is about 20. In the model the flux recorded in channel D1p makes 4-5 % of the flux recorded in channel D2e. The model calculations have shown that this value depends on the threshold of recording in the mixed channel (D1p).

At 3:48:00 and 5:22:30 minimum of curve D2e/D1p is observed what denotes practically complete absence of electrons recorded in channel D2e in these areas. Thus, it can be assumed that a proton flux detected by the mixed recording channel (D1p) prevails here, what is also confirmed by presence of fluxes detected in D2p channel at these moments (Fig.5).

In the area of background fluxes, "between" the radiation belts (in Fig.6 it is presented by sample points of time 4:26:30, 6:46:00, etc.) equality of fluxes recorded in channels D1p and D2e is observed. According to our calculations, in the areas of electron fluxes only up to 5% of electrons with energy above the threshold of those recorded in channel D2e can be absorbed in D1p. Hence 95 % of the flux recorded in the area of background fluxes in channel D1p with energy above threshold must be of no electronic nature and have the absorbed energy above that peak which electron leaves in the detector matrices, i.e., up to 5MeV [3]. The calculations and analysis allow affirming that the background fluxes are of mixed nature. As it will be shown below, similar data on background fluxes have been obtained in some other researches.

In the area of two “neighboring” crossings of the radiation belts, at descending and ascending orbit, at 5:56:00 and 6:07:00, considerable difference in the ratio of the fluxes D2e/D1p is observed, i.e., 9.68 and 21.2, respectively. And with an absolute reduction of the flux in channel D1e (see. Fig.6-b), the ratio D1e/D2e increased from 3 to 10. As model calculations on electron fluxes distribution between proton and electron channels, in the wide range of spectral distribution of primary electrons, have shown, such a change in ratio of indications for D1p and D2e is impossible for the case of isotropic angular distribution. Model studies of the recorded fluxes distributions have shown that this might happen not due to sharp changes in the electron spectral distribution but due to the predominance of angular distribution of the primary flux of electrons with wide angles (appropriate calculations are presented in section “Simulation”). In such a way a reference criterion for determining the degree of isotropy of the initial radiation flux was obtained; the effect of interaction between the device and the directed flux not getting normally on the sensitive surface of the detector was confirmed.

Even greater decline in the ratio D2e/D1p (Fig.6a, at 7:31:30; 7:42:00) is accounted not only for the predominance of wide angles in the primary flux, but also for the presence of the proton component in the mixed flux recorded in D1p channel comparable with electrons, as it was mentioned above.

Ratio D1p/D2e in the central part of БМА (at 7:06:00) shows prevalence of electron fluxes in the energy range of 0.35-0.95 MeV over proton fluxes in this area of space. Nevertheless, unlike the area of crossing radiation belts by the satellite, contribution of electrons to the proton channel is not dominant. As is clear from Fig.6a (at 6:52:00 and 7:06:00) the electron flux increase in channel D2e in the BMA area more than twice, compared to that in the RB crossing area, was accompanied by increase of the flux recorded in the channel D1p by more than 5 times. According to our model calculations, it could not happen exclusively due to the electron component detected by the mixed flux channel.

As it was noted earlier, the relative growth of electron component of the mixed signal in channel D1p was observed at prevalence of wide angles in the area of the flux detection by STEP-F device, and was accompanied by decrease in the integrated flux recorded by the device. In the central area of BMA, at high intensity, anisotropy of radiation fluxes, in particular lack of normal angles when radiation hits the device input window, is improbable.

Proceeding from the assumption of isotropic angular distribution of particles hitting the STEP-F device in the area of BMA, when using model calculations of fluxes distribution in channels D1p and D2e, we obtained the following distribution mode of the flux proton component recorded by the mixed channel D1p(see Fig.7):

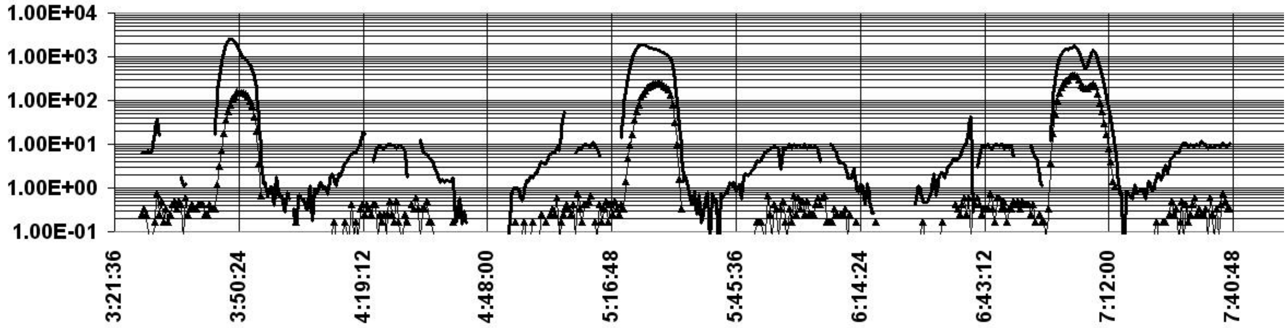


Fig.7. Spatial and temporal distribution of protons according to the data of D1p (bold line) and D2p (triangle marker) channels.

The developed model has allowed analyzing the relationship between electron fluxes recorded in different channels. An attempt was made to differentiate angular and spectral characteristics of the electron fluxes. Use of the developed model makes it possible to restore spectra both proton, and electron spectra of primary fluxes hitting the STEP-F device.

COMPARISON OF DATA FROM DETECTING MATRICES OF STEP-F DEVICE IN THE AREA OF BACKGROUND FLUXES WITH THOSE OBTAINED IN OTHER RESERCHES

In the area of the radiation belts crossing the electron fluxes are usually much slower as to the count rate than in the area of BMA (Fig.5,6), but they are accompanied by low-intensity, but spatially extended fluxes of particles. Channel that do not records electrons (D2p, Fig.5,7) reproduce this distribution.

First of all attention should be paid to the fluxes recorded in channels D2e and D1p (Fig.5). In the area of background fluxes, the latter ones recorded in channels D2e and D1p, have practically the same intensity (Fig.5). As it was shown above, the electron part of the flux in the mixed channel D1p should be considerably lower, more than five times than the flux recorded in channel D2e. The equality of the fluxes recorded in channels D1p and D2e, also occurs in some areas of BMA when electron flux recorded in channel D2e and even in D1e, is of the same value as the flux, recorded by the mixed recording channel D1p (Fig.6, time points 3:52:00, 5:26:00).

According to the simulation of STEP-F device operation equality of the particle fluxes recorded in channels D2e and D1p may indicate nothing but different nature of these particles.

Localization of equal fluxes of particles with different energies in one area of magnetosphere is possible only in case of different types of these particles (Fig.8)

Figure 9 presents the data from the satellite "Meteor-M # 1" [7], and Fig.10 from the device "Electron-M-Peska" which was also used in the "Coronas-photon" experiment [8]. Mixed nature of the background fluxes is proved by the results of similar experiments with "Coronas-photon" using "Electron-M-Peska" device [8] recording both the electron component of the flux in the energy range of 0.2-1MeV, and the proton component in the energy range of 4-16 MeV (Fig.9).

Distribution of electrons in the energy range of 100-300 keV and protons in the energy range of 0.8 -1 MeV marked by triangle, electron distribution with energy of more then 300 keV, marked by circle, and proton distribution with energy more then 8 MeV (marked by square) are presented in Fig.9.

The results received with "Electron-M-Peska" device working on the orbit at the same time and under the same conditions as the STEP-F device are presented in Fig.10, where electron distribution is marked as “e” and proton distribution was marked as “p”. As the figure shows the number of high energy electrons (more then 1 MeV) is significantly less then that of protons in the energy range of 4-16 MeV. But electron flows with energy more then

200 keV significantly stronger then those of protons for any energy, especially under radiation belt crossing. For us it is important that proton were registered during the whole process of measuring. The same results were obtained when modeling and processing the STEP-F data (see Fig.7).

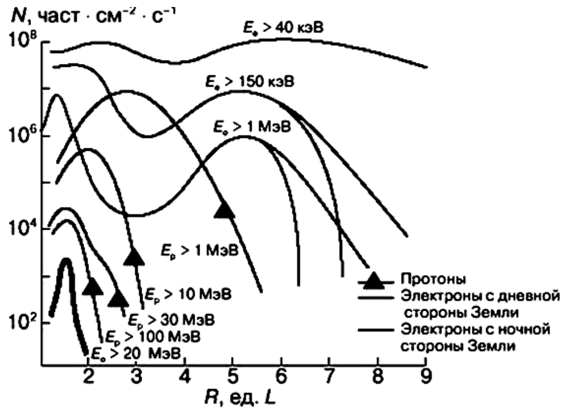


Fig.8. Spectral distribution of particles in the area of magnetosphere [6]

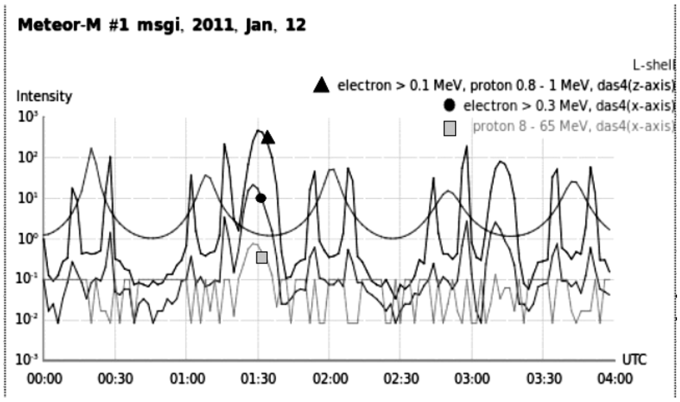


Fig.9. Variations of electron fluxes with energy of 0.1-0.3 MeV and proton fluxes with energy of 8-65 MeV in the period of UTC making 4 hours on January12, 2011, according to the data obtained from "Meteor 3M" satellite.

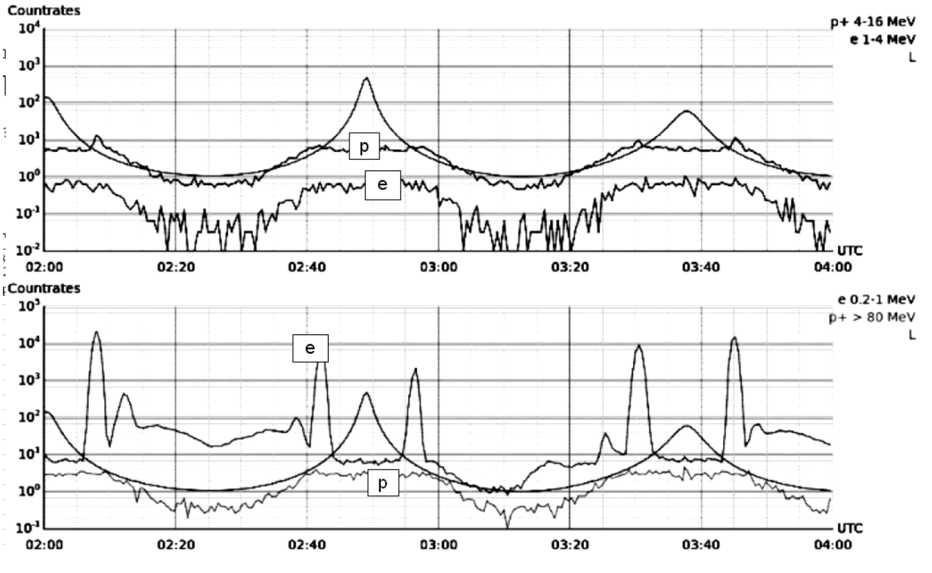


Fig.10. Variations of electron fluxes with energy of 0.2-4 MeV and protons fluxes with energy 5-16 MeV and above 80 MeV in the period of UTC making 2 hours on July 6, 2009 received on "Electron-M-Peska".

In the course of all the loops “Meteor-M # 1" recorded protons in the energy range of 8 - 65 MeV, not only in the BMA area (see. as example, Figure 9, UTC 1:20 - 1:35), but also in the area of background fluxes, as well as electrons in the energy range of > 0.3MeV.

CONCLUSION

Presence of areas with spatially separated electron and proton fluxes in the part of magnetosphere under study allows to analyze the mechanism of recording of the mixed flux in channel D1p.

The developed computer model of electron flux recording by the device allowed to define distribution principle regularity for electrons with the same energy between different channels designed for recording particles.

When measuring proton fluxes, one may define the electron component contribution to signal D1p by electron spectral distribution law, and can be estimated and calculated for concrete magnetospheric and other conditions.

When the proton fluxes are absent the channel D1p records electron component of the flux, its high-energy part, when the electron with its range of path exceeding the value of the silicon matrix thickness, still leaves all its energy in D1 channel. The electrons are recorded by the proton channel both due to the wide angle of their income, and due to the wide scale of the electron energy absorption probabilities (Fig.3b).

Possibility to differentiate the proton and electron fluxes when processing the experimental data would allow analyzing the spectral distribution law for electrons and protons.

The detector channels which do not record the electron component of particle flux, as well as relation of the fluxes recorded in D2e and D1p would allow detecting presence of ions in the background fluxes for certain.

The author thanks Ph.D. A.V. Dudnik, for the presented STEP-F device parameters and the primary data obtained through the use of CORONAS-PHOTON satellite.

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