A development of XREC data processing technique based on computer recognition and analysis of CCD-images

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***Abstract*. A method of automatic XREC data processing has been developed which is based on recognition and analysis of graphical images captured by a wide-format professional CCD-scanner through digital scanning of X-rays films. Applied statistical algorithms of recognition allow to process in a complete automatic manner a single electron-photon cascade producing a correspondent darkness spot on a film accounting for spurious film defects and background fluctuations as well as a narrow group of overlapping darkness spots occurring in gamma-ray families.**

Efficiency of Expectation-Maximization (EM) algorithm for decryption of overlapping narrow bundles of showers is examined with simulated events calculated by ECSim 2.1 code of determination of XREC response. The elaborated code contains the EM algorithm together with an agglomerative clustering strategy to estimate the number of clusters which give the best fit of the data. Relevancy of the applied algorithms to the concerned problem is discussed.

I. INTRODUCTION

The interactions at energies E_0 > 100 TeV are studied using the method of large X-ray emulsion chambers (XRECs) exposed at mountain heights. The XREC method allows one to design detectors with an area up to 1000 m^2 and accumulate experimental data (single exposure) during a year, which is extremely important in investigation of low-intensity particle fluxes. For more efficient application of the XREC method, automatic processing of a very large amount of experimental data is necessary.

II. THE COMPLEX FOR AUTOMATIC PROCESSING OF EXPERIMENTAL DATA

The method for automatic processing of XREC data based on recognition and analysis of graphic images (bitmaps) obtained at scanning images on X-ray films using special measuring complex is developed.

The basis of the measuring complex is a professional large-format Cezanne Elite FT-S5500 scanner controlled by a microprocessor server (Macintosh OS) with the following characteristics: scanning area 420mṃ×290mm (*A*3+); maximum resolution 5200 pixels/inch; transparency region 16 bit (0–65535);dynamic depth 4.2*D*; graphical data format tiff. The tiff file formed by the scanner using the standard software contains the graphic bitmap of the image in the form of a 2D array. The coordinates *x* and *y* of each pixel (bitmap element) correspond to the transparency value *z* in the range from 0 to 65535 (16 bit mode) [1].

The mass scanning working regime, which is determined by the optimal ratio of the measurement precision and the file size (information volume), makes 2000 pixel/inch, which corresponds to a pixel size of 12.7 µṃ×12.7 µm. In the “Pamir–Chakaltaya” experiment [2], the dependences $E = f(D,t)$obtained for a standard MF-2 micro photometer are still used; for this micro photometer, measurements are performed using circular diaphragms, therefore, the scanner is calibrated for MF-2 using homogeneous dark macroscopic areas (threepoint radioactive β-source $Sr^{90}+Y^{90}$).

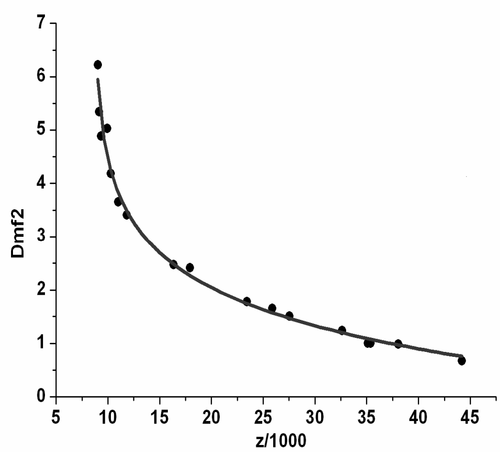

Fig. 1. Correlation between the total energy of “measured” (ordinate axis) and incident (abscissa axis) families.

The calibration dependence has the form

$$d(z) = a - b \cdot log(z + c), \qquad (2)$$

where a = 12.54, b = 1.12, and c = –8690.

The quality of the scanner calibration is verified by processing the test quanta of the "Pamir–Chakaltaya" collaboration, which were earlier used to standartize microphotometers (see Fig. 4).

III. ALGORITHMS OF RECOGNITION

The program clusters the image, uniting closely situated pixels. Then the program determines the number of electron–photon cascades in the cluster, tries to separate them (Example of clustering procedure work see Fig.2 and Fig.3)

The event recognition on the scanned film is based on the assumption that the real spot from the electron–photon cascade has the Gaussian darkening density distribution (see Fig. 5).

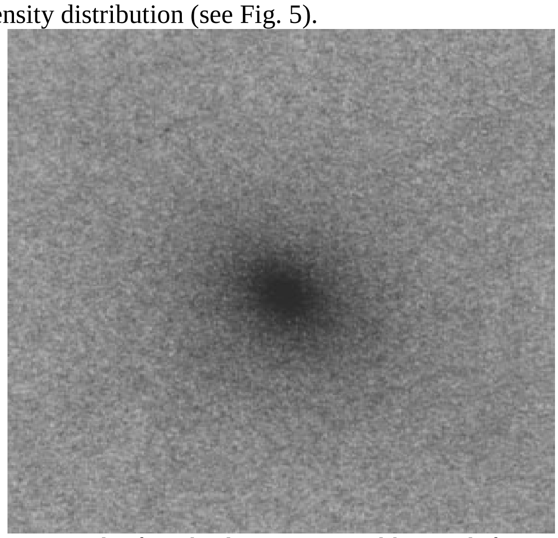

Fig. 2 Example of graphical images captured by a wide-format professional CCD-scanner.

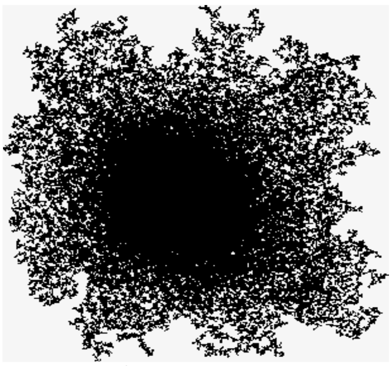

Fig. 3 Example of clustering procedure work (expanded scale)

For decryption of overlapping narrow bundles of showers (the solution of the problem of mixing (mixture separation) of Gaussian distributions) EM – algorithm have been applied. The program automatically tries to estimate the parameters of the distributions. Efficiency has been examined with simulated events calculated by ECSim 2.1 code of determination of XREC response and real event like γ-families. For simulated events program displays more then 90% coincidence, for real event – about 80%.

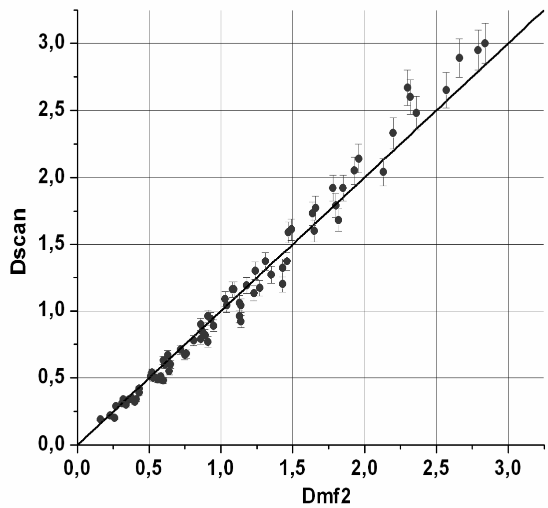

Fig. 4. Correlation between the darkening from test quanta of the "Pamir–Chakaltaya" collaboration, measured by the scanner (ordinate axis) and MF-2 (abscissa axis).

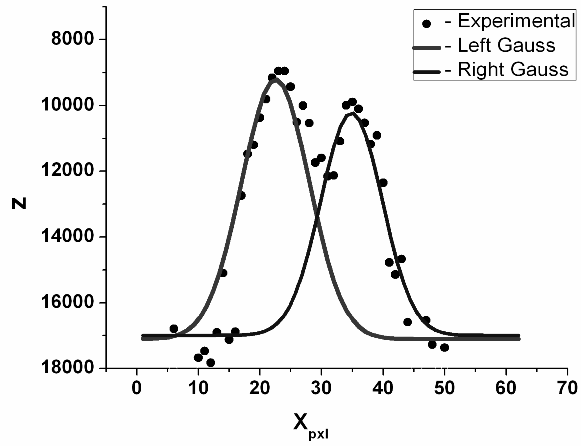

Fig. 5 Example of spatial distribution of darkening density in an electron–photon cascade (two closely situated events). Values from the scanner are plotted along the ordinate axis and distance in pixels (1 pixel = 12.7 μm) is plotted along the abscissa axis.

IV. CONCLUSIONS

(1). The comparison of darkening densities measured by the Cezanne Elite FT-S5500 CCD scanner and the MF-2 micro photometer yields agreement with aprecision of 10–12%. The Cezanne Elite FT-S5500scanner allows positioning of electron–photon cascade centers with an error of 12.7 μm.

(2) The method provides separation of electron–photon cascades in the darkening range 0.4–3.5*D*.The admixture of background events does not exceed15%, as compared to the technique of the “Pamir” experiment.

(3) For decryption of overlapping narrow bundles of showers) EM – algorithm displays good response, bad must be improved for real event with high particle multiplicity.

V. ACKNOWLEDGMENTS

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VI. REFERENCES

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