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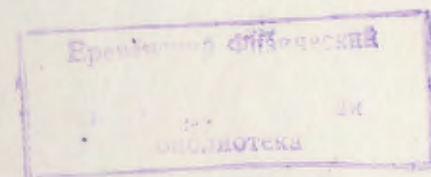
ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ  
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A COMBINKD METHOD FOR DETERMINATION OF GAS PARAMETERS



ЦНИИатоминформ  
ЕРЕВАН - 1989

Ս.Վ. ՅԵՐ-ԱՆՏՈՆԹԱՆ

ԼՄՀ ՊԱՐԱՄԵՏՐԵՐԻ ՈՐՈՇՄԱՆ ՀԱՍՏԱԿՑՎԱԾ ՄԵԹՈԴ

Առաջարկված է ԼՄՀ պարամետրերի որոշման համակցված մեթոդ, հիմնված  $\chi^2$  ֆունկցիոնալի նվազեցման վրա՝ ԼՄՀ առանցքի տարածական կոորդինատների արժեքների ստացման համար, և ճշմարտանմանության հավասարումների անալիտիկ լուծումների օգտագործման վրա՝ ԼՄՀ մասնիկների կյանքի և լրիվ թվի հաշվարկի համար:

Երևանի ֆիզիկայի ինստիտուտ  
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In experiments on the study of extensive air showers (EAS) it is necessary to determine the age ( $s$ ) and the number of particles ( $N_0$ ) in EAS and the coordinates ( $x_0, y_0$ ) of the observation plane's traversal by EAS cores. The unknown quantity  $N_0, s, x_0, y_0$  are the parameters of the EAS charged component spatial distribution function, the arguments of which are the coordinates ( $x_i, y_i, i=1, \dots, m$ ) of  $m$  detectors in experiment. Restoration of the parameters  $N_0, s, x_0, y_0$  by the experimentally found distribution of the charged-component density is based on the method of the  $\chi^2$  minimization at an *a priori* known theoretical function of spatial distribution. As such function the Nishimura-Kamata-Greisen (NKG) approximate formula

$$f_i = N_0 \cdot g_i = N_0 c(s) \frac{S_i}{R_M^2} z_i^{s-2} (1+z_i)^{s-4.5} \quad (1)$$

is widely used, where  $z_i = R_i/R_M$ ,  $R_i = \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2}$ ,  $c(s)$  is normalization determined from the condition  $\int g \cdot 2\pi R dR = 1$ ,  $S_i$  is the area of detector.

In ref.[1] is shown that the linear dependence of the function (1) on  $N_0$  allows to analytically solve the likelihood equation for  $N_0$ :

$$N_0 = \sum_i \frac{n_i g_i}{\sigma_i^2} / \sum_i \frac{g_i}{\sigma_i^2}, \quad (2)$$

where  $\sigma_i$  is the error of measurement of the number of particles  $n_i$  in the experiment. The parameters  $s, x_0, y_0$  necessary for the realization of the formula (2), are determined by minimization of the functional  $\chi^2$  which consists of the normalized  $(n_i / \sum n_i)$  number of particles in

detectors, and the corresponding values of the NKG function ( $g_i/\sum g_i$ ). It allowed to reduce the traditional four-parameter problem to a three-parameter one and thus, to reduce the errors and the shift in determination of EAS parameters [1].

Let us transform the experimentally determinable values of  $n_i$  (the number of particles in the  $i$ -th detector) to  $\{lm_i - \langle lm \rangle\}$ , where  $\langle lm \rangle = \sum lm_i / m$ . The corresponding transformation of the theoretical function is

$$lf_i = (s-2)lz_i + (s-4.5)l(1+z_i), \quad (3)$$

where the operator  $l a_i = l m_i - \langle l m \rangle$ .

As is seen from (3), the function  $F_i = lf_i$  is independent of  $N_0$  and is in a linear dependence on  $s$ , which allows by solving the equation

$$\frac{\partial \chi^2}{\partial s} \equiv \sum_{i=1}^m \frac{1}{(\sigma_i^*)^2} \frac{\partial F_i}{\partial s} (F_i - l n_i) = 0 \quad (4)$$

to obtain an analytical expression for the parameter  $s$ , which is a function of  $x_0$  and  $y_0$ :

$$s = \frac{\sum_i \left\{ \frac{1}{(\sigma_i^*)^2} (lz_i + l(1+z_i))(ln_i + 2lz_i + 4.5l(1+z_i)) \right\}}{\sum_i \left\{ \frac{1}{(\sigma_i^*)^2} (lz_i + l(1+z_i)) \right\}}, \quad (5)$$

where  $(\sigma_i^*)^2$  is dispersion of the quantity  $ln_i$  measured in the experiment.

Thus, the three-parameter problem is reduced to a two-parameter minimization of the functional

$$\chi^2 \equiv \chi^2(x_0, y_0) = \sum \frac{(lf_i - l n_i)^2}{(\sigma_i^*)^2}, \quad (6)$$

where the parameter  $s$  is defined in the form of (5).

Simulation of the real experimental situation [2,3] has shown that the combined method offered, which consists in minimization of the functional (6) for determination of  $x_0, y_0$  with a following use of (2) and (5), allows to obtain unshifted and effective estimations of the parameters  $N_0, s, x_0, y_0$  with an accuracy better than four-parameter [4] and three-parameter [1] minimizations. In the procedure of minimization of (6) it is enough to choose the values  $x_0^{(0)} = x_k, y_0^{(0)} = y_k$  ( $n_k = \max\{n_i\}$ ) as zero approximations  $(x_0^{(0)}, y_0^{(0)})$  of the parameters  $x_0$  and  $y_0$ .

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