ИНДЕКС 3649

ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

Preprint YERPHI-1168(45)-8

ԵՐԵՎԱՆԻ ՖԻԶԻԿԱՅԻ ԻՆՍՏԻՏՈՒՏ
ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ
YEREVAN PHYSICS INSTITUTE

S.V. TER-ANTONIAN

A COMBINED METHOD FOR DETERMINATION OF EAS PARAMETERS

ЦНИИатоминформ
ЕРЕВАН - 1989

Նախատիպ ԵՖԻ-1168(45)-89

Մ.Վ. ՏԵՐ-ԱՆՏՈՆՅԱՆ

ԼՄՀ ՊԱՐԱՄԵՏՐԵՐԻ ՈՐՈՇՄԱՆ ՀԱՄԱԿՑՎԱԾ ՄԵԹՈԴ

Առաջարկված է ԼՄՀ պարամետրերի որոշման համակցված մեթոդ, հիմնված χ^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
Երևան 1989

In experiments on the study of extensive air showers (EAS) it is necessary to determine the age (s) and the number of particles (N_e) in EAS and the coordinates (x_o, y_o) of the observation plane's traversal by EAS cores. The unknown quantity N_e, s, x_o, y_o 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_e, s, x_o, y_o by the experimentally found distribution of the charged-component density is based on the method of the χ^2 minimization at an *a priori* known theoretical function of spatial distribution. As such function the Nishimura-Kamata-Greisen (NKG) approximate formula

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

is widely used, where $z_i = R_i/R_M$, $R_i = \sqrt{(x_i-x_o)^2+(y_i-y_o)^2}$, $c(s)$ 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_e allows to analytically solve the likelihood equation for N_e:

$$N_e = \sum_i \frac{n_i g_i}{\sigma_i^2} \Big/ \sum_i \frac{g_i}{\sigma_i^2}, \qquad (2)$$

where σ_i is the error of measurement of the number of particles n_i in the experiment. The parameters s, x_o, y_o necessary for the realization of the formula (2), are determined by minimization of the functional χ^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 $\{ln_i - \langle ln \rangle\}$, where $\langle ln \rangle = \sum ln_i/m$. The corresponding transformation of the theoretical function is

$$\mathbb{L}f_i = (s-2)\mathbb{L}z_i + (s-4.5)\mathbb{L}(1+z_i) \ , \qquad (3)$$

where the operator $\mathbb{L}a_i = lna_i - \langle lna \rangle$.

As is seen from (3), the function $F_i \equiv \mathbb{L}f_i$ is independent of N_e and is in a linear dependence on s, which allows by solving the equation

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

to obtain an analytical expression for the parameter s, which is a function of x_o and y_o:

$$s = \frac{\sum_i \left\{ \frac{1}{(\sigma_i^*)^2} (\mathbb{L}z_i + \mathbb{L}(1+z_i))(\mathbb{L}n_i + 2\mathbb{L}z_i + 4.5\,\mathbb{L}(1+z_i)) \right\}}{\sum_i \left\{ \frac{1}{(\sigma_i^*)^2} (\mathbb{L}z_i + \mathbb{L}(1+z_i)) \right\}} \ , \qquad (5)$$

where $(\sigma^*)^2$ is dispersion of the quantity $\mathbb{L}n_i$ measured in the experiment.

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

$$\chi^2 \equiv \chi^2(x_o, y_o) = \sum \frac{(\mathbb{L}f_i - \mathbb{L}n_i)}{(\sigma_i^*)^2} \ , \qquad (6)$$

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_o, y_o with a following use of (2) and (5), allows to obtain unshifted and effective estimations of the parameters N_e, s, x_o, y_o 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 $x_o^{(o)} = x_k$, $y_o^{(o)} = y_k$ $(n_k = \max\{n_i\})$ as zero approximations $(x_o^{(o)}, y_o^{(o)})$ of the parameters x_o and y_o.

References

1. Бабаджанян О.С., Тер-Антонян С.В. Препринт ЕФИ-1031(8)-89.
2. Авакян В.В. и др. ВАНТ, сер: ТФЭ, 1984, вып. 3(20), с.69.
3. Базаров Е.В. и др. ВАНТ, сер: ТФЭ, 1986, вып. 5(31), с.3.
4. Афанасьев Б.Н. и др. ВАНТ, сер: ТФЭ, 1982, вып. 4(13), с.49.

The manuscript was received June 6, 1989

С.В. ТЕР-АНТОНЯН

КОМБИНИРОВАННЫЙ МЕТОД ОПРЕДЕЛЕНИЯ ПАРАМЕТРОВ ШАЛ

(на английском языке, перевод Г.А. Папяна)

Редактор Л.П.Мукаян

Технический редактор А.С.Абрамян

Подписано в печать 31/X.89 ВФ-02207 Формат 60×84×16

Офсетная печать. Уч.изд.л., 0,5 Тираж 299 экз.Ц. 8 к.

Зак.тип. 1847 Индекс 3649

Отпечатано в Ереванском физическом институте

Ереван-36, ул. Братьев Алиханян 2.

The address for requests:
Information Department
Yerevan Physics Institute
Alikhanian Brothers 2,
Yrevan, 375036
Armenia, USSR